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LOCOMOTIVE DESIGN.*

By F. J. Cole, Assistant Mechanical Engineer, Schenectady Locomotive Works.

MOMENTUM AND ACCELERATION.

The effect of velocity to assist the tractive power of a locomotive in surmounting grades of moderate length is generally considered from two points of view, (a) the determination of the grades on a new road or the reconstruction of the grades on an old road and (b) the hauling power or tonnage rating of a locomotive on existing railroads where the ruling grades are approached at certain allowable maximum velocities. In both, the principles involved are the same, although the application is different. In this paper the argument will be confined to the maximum hauling power at varying speeds on roads already built.

In a number of tonnage tests the published data and figures were quoted to prove that under some conditions the hauling power of certain locomotives was greater than could be accounted for by the usual formulae employed in estimating the tractive force. So that after assuming the highest mean effective pressure allowable and the lowest resistance for rolling friction, curves, etc., and making proper deductions for the weight of the engine and tender, the tonnage actually hauled was considerably in excess of the theoretical. As the resistance due to the grade is the weight actually lifted a certain number of feet in a given space, it is therefore accepted as a mathematical fact which does not admit of discussion.

It seems doubtful whether in all cases the velocity of approach, the gradually diminishing speed on the grade, and the decreased velocity at the summit have always been duly considered in relation to their effect in increasing the tractive power of the engine and enabling it to ascend grades with trains requiring a greater tractive force than that possessed by the engine. The force, momentum or kinetic energy contained or stored up in a moving body is most readily estimated by comparing it to the acceleration of gravity on a body falling freely from a height. The space through which a body will fall in one second of time from a state of rest is 16.1 ft., and the velocity at the expiration of one second is 32.2 ft. In two seconds the space fallen through is 48.3 ft. and the velocity 64.4 ft. This is expressed in the well-known formula:

$$h = \frac{V^2}{2g} = \frac{V^2}{64.4}$$

Let S = space in feet.
t = time in seconds.
K = foot-pounds.
K_2 = foot-pounds per ton.
V = final velocity in feet per second.
M = speed in miles per hour.
W = weight in pounds.
R = resistance in pounds per ton.
h = height in feet.
g = force of gravity, 32.2.
f = force in pounds.

The kinetic energy of a moving body is able to lift the body to a height equal to that through which it must fall to produce the same velocity if allowed to fall freely. For example, the energy in a train moving at 30 miles per hour is equal to lifting the whole train up vertically 30.1 ft., as 30 miles per

$$\text{hour} = \frac{30 \times 5{,}280}{60 \times 60} = 44 \text{ ft. per second,}$$

$\frac{V^2}{2g} = \frac{44^2}{64.4} = 30.1$ ft. fall to produce a velocity of 44 ft. per second or 30 miles per hour. So that apart from the rolling friction and the energy used in overcoming it, the lifting power for any speed can easily be determined by finding the drop in feet required to produce that speed. This is given in table No. 1.

TABLE I.

Falling bodies: Height of fall required to produce a given velocity.

$$h = \frac{V^2}{2g}$$

M. Velocity, miles per hour.	V. Velocity, feet per second.	Fall in feet.
5	7.3	0.8
10	14.6	3.3
15	22.	7.5
20	29.3	13.3
25	36.6	20.8
30	44.	30.1
35	51.3	40.8
40	58.6	53.3
45	66.	67.6
50	73.3	83.4
55	80.6	100.8
60	88.	120.2
65	95.3	141.0
70	102.6	163.4
80	117.3	213.5
90	132.	270.5
100	146.6	333.6

The kinetic energy of a moving train is also influenced by the rotative energy of the wheels and axles which absorb or give out power as their speed is accelerated or retarded. The wheels after they are in motion and spinning around like so many small fly-wheels, are sources of energy and appreciably increase the total energy of a moving train, when the speed is reduced. For modern cars, an average of 5 per cent. increase may be added to Table I. for the rotative energy of the wheels. (See Wellington's "Location of Railroads," page 334, and Proceedings Railway Master Mechanics' Association, 1898, page 220, for the detailed methods of estimating the energy of rotation.) Table II. gives the kinetic energy or the height to which a moving body can be raised, for different speeds, in miles per hour plus 5 per cent. added for the rotative energy of the revolving wheels.

The resistance of loaded cars to motion on straight, level track is variously estimated by competent observers to be from 3½ to 6 lbs. per ton of 2,000 lbs., at slow speeds of say 10 miles per hour. The D. K. Clark formula, in which $R = \frac{M^2}{171}$, based on the theory that the resistance increased as the square of the speed, has been known for several years to give entirely too high resistances at anything but very slow speeds. The

*For previous article see Vol. LXXIV., page 307.

TABLE II.

Kinetic Energy of a Moving Body, Plus 5 per cent. for Revolving Energy of Wheels and Axles.

$$S = 1.05 \frac{V^2}{2g}. \quad \frac{M\ 5280}{3600} = M\ 1.466. \quad S = \frac{1.05 \times (M\ 1.466)^2}{64.4} = M^2\ .03508.$$

Miles per hour.	0	1	2	3	4	5	6	7	8	9
0	.....	.....	.....	.....	.....	.9	1.3	1.7	2.2	2.8
10	3.5	4.2	5.0	5.9	6.9	7.9	9.0	10.0	11.3	12.6
20	14.0	15.4	17.0	18.5	20.2	21.9	23.7	25.5	27.5	29.5
30	31.6	33.7	35.9	38.2	40.5	42.9	45.4	48.0	50.6	53.3
40	56.1	58.9	61.8	64.8	67.8	71.0	74.1	77.3	80.7	84.1
50	87.6	91.1	94.7	98.4	102.2	105.8	109.9	113.8	117.9	122.0
60	126.2	130.4	134.7	139.1	143.5	148.0	152.7	157.6	162.0	166.8
70	171.7	176.6	181.6	186.7	191.9	197.1	202.4	207.7	213.2	218.7
80	224.3	229.9	235.6	241.4	247.3	253.2	259.2	265.2	271.4	277.6

The above table represents the heights in feet to which a body moving at various velocities can be raised by its kinetic energy, provided the motion is retarded without friction and the revolving energy of the wheels equals 5 per cent.

"Engineering News" formula, in which $R = \frac{M}{4} + 2$, is probably used to a greater extent at present than any other. It is probable that the resistances given by this formula are too high, as the experiments conducted by the Baldwin Locomotive Works resulted in their using the formula $R = \frac{M}{6} + 3$. The conclusions of the late D. L. Barnes were that the resistance of passenger trains was 11 lbs. at 55, 12 lbs. at 65 and 14 lbs. at 75 miles per hour. The resistance due to grades alone is 20 lbs. per ton for each 1 per cent. of grade, or $\frac{2,000}{100} = 20$ as the entire load is lifted 1 ft. high in 100 ft. Expressed in feet per mile the resistance equals the number of feet $\times$ .37898 —although the approximation of 0.38 is commonly used. Table III. gives this in convenient form.

TABLE III.

Resistance of Grades in Feet per Mile per Ton (2,000 pounds).
$R = \text{Rise} \times .37878.$

Feet per mile.	0	1	2	3	4	5	6	7	8	9
1	....	.378	.76	1.14	1.52	1.8	2.3	2.7	3.0	3.4
10	3.8	4.2	4.6	4.9	5.3	5.6	6.1	6.5	6.8	7.2
20	7.6	8.0	8.4	8.7	9.1	9.4	9.9	10.3	10.6	11.0
30	11.4	11.8	12.2	12.5	12.9	13.2	13.7	14.1	14.4	14.8
40	15.2	15.6	16.0	16.3	16.7	17.0	17.5	17.9	18.2	18.6
50	18.9	19.4	19.8	20.1	20.5	20.8	21.3	21.7	22.0	22.4
60	22.7	23.2	23.6	23.9	24.3	24.6	25.1	25.5	25.8	26.2
70	26.5	27.0	27.4	27.7	28.1	28.4	28.9	29.3	29.6	30.0
80	30.3	30.7	31.1	31.5	31.9	32.2	32.6	33.0	33.4	33.8
90	34.1	34.5	34.9	35.3	35.6	36.0	36.4	36.8	37.2	37.5
100	37.8	....	....	....	....	....	....	....	....	....

Taking the resistance at slow speeds at 5 lbs. per ton, the equivalent grade on which a train if once started would just overcome the rolling friction and continue moving, at slow speed is 0.25 per cent., or 13.2 ft. per mile. This amount deducted from or added to any grade will equal the resistance of the train on straight level track.

If a train running from A to B, Fig. 1, approaches the foot of a 1 per cent. grade (52.8 ft. per mile) at 30 miles per hour and passes the summit at 5 miles per hour, the total kinetic energy absorbed is equal to raising the entire train 30.7 ft. The height for a speed of 30 miles per hour is 31.6, and for 5 miles is 0.9 ft. (see Table II.), and 31.6 — 0.9 = 30.7. If the engine only exerts a continuous tractive force equal to the rolling friction of the train, the grade, whose total height is 30.7 ft., can be surmounted by the kinetic energy of the train alone without any assistance from the engine, except to overcome the frictional or speed resistance of the moving train.

The effect of velocity to reduce a grade whose total rise is much greater than in the preceding example is shown in Fig. 2. The result is a reduction of the 2 per cent. grade along its entire length. Suppose a train is required to pass over the summit of the grade at 5 miles per hour, when the speed of approach at H is 30 miles per hour. The actual energy is equal to raising the train 30.7 ft. as in Fig. 1. From the total height of 61.4 may be deducted 30.7 ft., so that the 2 per cent. grade can really be operated with no greater tractive effort of the engine than a 1 per cent. grade. The dotted line shows the apparent reduction of this grade due to velocity. Had the velocity at H been 42 instead of 30 miles per hour, the entire 2 per cent. grade 3,070 ft. long having a total rise of 61.4 ft., could be surmounted by the kinetic energy alone, provided the engine exerted a uniform tractive force of 7½ to 8 lbs. per ton, or enough to overcome the rolling friction for an average speed of 23½ miles per hour. If a train starts from G, Fig. 2, and attains a velocity of 30 miles per hour at H after running

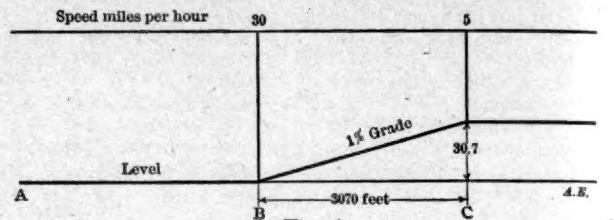

Fig. 1

3,005 ft. on straight level track, the force required to accelerate the speed from a state of rest will be 20 lbs. per ton of 2,000 lbs. (See Table IV.) To this must also be added the resistance per ton required to overcome the rolling friction. As the average speed is 15 miles per hour the resistance will equal about 6 lbs. The total force required will be 26 lbs. per ton for acceleration and rolling friction.

There is a limit to the length of grade on which the velocity of approach is beneficial; where the length is so great or the total rise exceeds the limitations imposed by the maximum speed. It will then be found that a heavier train can be hauled at a slow steady pull than if the momentum of the train is taken into consideration, apart from the maximum power of the locomotive at 8 or 10 miles per hour. It is difficult to locate this point off-hand with great exactness for all kinds and weights of locomotives, as the principal loss of efficiency is due to the increase of piston speed causing a decrease in the mean effective pressure in the cylinders. This in turn depends upon the diameter of drivers and stroke. When these are known the limit can easily be determined. For example, an engine with 60-in. driving wheels and 28-in. stroke will pull, we will say, 1,200 tons (including the weight of engine and tender) up a 1 per cent. grade 10,000 ft. long at slow speeds. This means a total difference of elevation of 100 ft. in a distance of 10,000 ft. Suppose the grade is approached at a maximum allowable speed of 30 miles an hour, and the summit

TABLE IV.

Force and Space Required to Accelerate One Ton (2,000 lbs.) from a State of Rest to Various Velocities.

$$S = \frac{31.05\ V^2}{F}.$$

Velocity, miles per hour.	V. Velocity, feet per second.	V^2. Square of velocity, feet per second.	Foot pounds per ton $31.05V^2$.	Space in feet to accelerate 1 ton (2,000 lbs.) with a uniform force of 5 lbs.	10 lbs.	15 lbs.	20 lbs.	25 lbs.	30 lbs.
5	7.3	53.3	1,655	331	165	110	83	66	55
10	14.6	214	6,645	1,329	664	443	332	265	221
15	22.0	484	15,028	3,005	1,502	1,001	751	601	500
20	29.3	858	26,641	5,328	2,664	1,776	1,332	1,065	888
25	36.6	1,339	41,576	8,315	4,157	2,771	2,078	1,663	1,385
30	44.0	1,936	60,113	12,022	6,011	4,007	3,005	2,404	2,003
35	51.3	2,632	81,724	16,345	8,172	5,448	4,086	3,269	2,724
40	58.6	3,434	106,626	21,325	10,662	7,108	5,033	4,265	3,554
45	66.0	4,356	135,254	27,051	13,525	9,016	6,762	5,410	4,508
50	73.3	5,373	166,832	33,366	16,683	11,122	8,342	6,673	5,561
55	80.6	6,496	201,701	40,340	20,170	13,446	10,085	8,068	6,723
60	88.0	7,744	240,451	48,090	24,045	16,030	12,023	9,618	8,015
65	95.3	9,082	281,996	56,399	28,199	18,799	14,100	11,279	9,399
70	102.6	10,527	326,863	65,372	32,686	21,791	16,343	13,074	10,895
75	109.9	12,078	375,022	75,004	37,502	25,001	18,751	15,001	12,500
80	117.3	13,759	427,186	85,437	42,718	28,479	21,359	17,087	14,239
90	132.0	17,424	541,015	108,203	54,101	36,067	27,050	21,640	18,034
100	146.6	21,491	667,295	133,459	66,729	44,486	33,364	26,691	22,243

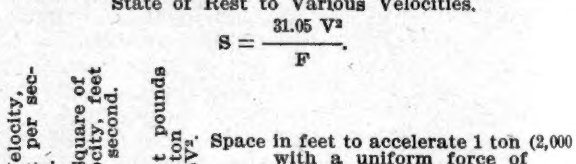

Fig. 2

passed at 5 miles an hour, then the average velocity is $\frac{30+5}{2} = 17.5$ miles per hour and an average piston speed of 457 ft. per minute. The mean effective pressure for this piston speed will be about 68 per cent. of boiler pressure. (See Fig. 1, American Engineer, June, 1900, page 176.)

Assuming that 85 per cent. is the maximum M. E. P. at slow speeds, then there is a loss of $\frac{85-68}{85} = 20$ per cent., due to increase of piston speed.

The resistance of loaded cars at slow speeds on level straight track at 8 to 10 miles per hour is about 5 lbs. per ton, and at 17 or 18 miles per hour, about 6½ lbs. If the train approaches the foot of the grade at a speed of 30 miles per hour and passes the summit at 5 miles per hour, then the total kinetic energy will equal a decrease in the grade of 30.7 ft., making an apparent grade of 0.69 per cent. instead of 1.00 per cent.

At slow speeds the resistance on a 1 per cent. grade is about $20 + 5 = 25$ lbs. per ton. The resistance on 0.69 per cent. grade at an average speed of 17.5 miles is approximately $13.8 + 6.5 = 20.3$ lbs. per ton. Then, the percentage of decrease in resistance equals $\frac{25-20.3}{25} = 18.8$.

As the decrease in M. E. P. caused by higher piston speed was 20 per cent., it is obvious that no increase in weight of train can be made by approaching this grade at the speed and under the conditions named, provided ample steam can be generated by the boiler. If an up grade is preceded by a down grade considerable economy in the use of steam is of course possible by utilizing the energy gained going down to assist in overcoming or partially overcoming the ascent on the other side.

The space through which a body must pass in order to attain a given velocity when accelerated by a uniform force is equal to half the final velocity multiplied by the number of seconds:

$$S = \frac{Vt}{2}, t = \frac{S}{0.5V} = \frac{S2}{V}.$$

$$K = \frac{W V^2}{2 g}.$$

$$K = \frac{2000 V^2}{2 g} = \frac{2000 V^2}{64.4} = 31.05 V^2.$$

$$f = \frac{V^2 W}{2 s g}.$$

From the diagram Fig. 3 the acceleration of one ton with forces from 5 to 500 lbs. at different velocities can be readily obtained. The distance run in feet is given on the horizontal line, the velocities in miles per hour on the vertical line, the time on the straight radial lines and the force in pounds on the curved radials.

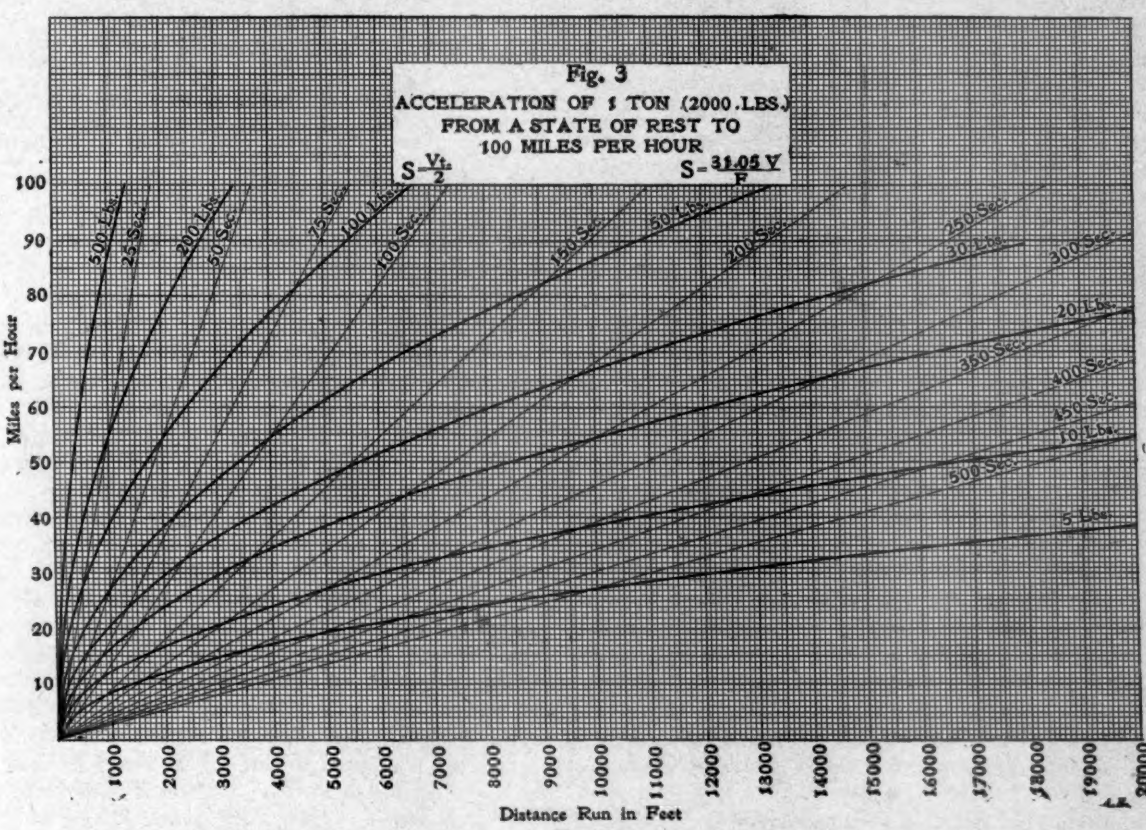

Fig. 3.

That the locomotive is likely to make remarkable progress in the immediate future is apparent to those who are in touch with the thought of leaders in this direction. Mr. S. M. Vauclain at a recent meeting of the New England Railroad Club made some remarks which we consider prophetic. He said: "The improvement of the locomotive will embrace the further development of those features invented in the previous century, compounding of all locomotives upon some system now used, or yet to be invented, will be almost universal, the wide firebox and tubular boiler will be carried to the limit of human ability to manage it. This will give place to the water-tube boiler, espeially for high speeds. Who that is here to-night is destined to be the instrument of its introduction? Already bright minds are employed in designing a boiler of this description which can be placed on our arrangement of cylinders, underframing, wheels and machinery—a system that will give three times the heating surface for an equivalent weight. High speeds will be used for all trains carrying human freight, but long and heavy express trains will be handled with facility by the improved high-pressure compound locomotives of that period. The loading gage of our trunk lines will not prevent doubling, or even trebling, the power of locomotives for freight traffic. Double bogie engines similar to those used abroad, but on the American idea, will be employed."

A GENERAL MANAGER'S SUGGESTIONS TO MOTIVE POWER OFFICERS.

By J. Kruttschnitt,

Fourth Vice-President and General Manager,

Southern Pacific Company.

In view of the approaching conventions of motive power officers, it may be in order to offer some suggestions as to ways in which they may assist materially in efforts to increase net earnings. It is a physical impossibility for me to offer anything like a connected article, but I will outline briefly such questions and matters as our own experience has shown to be of vital importance for successful management.

The far-reaching effects of bad water would lead me to place its improvement by chemical treatment as first in importance of the problems that confront motive power officers of the present day. The extent to which bad water will interfere with traffic and run up expenses is, I fear, hardly appreciated by either operating or motive power officers east of the Mississippi River, but on the far Western lines renewals of tubes and of fire boxes, delays to traffic through leaks and the extinguishing of fires of locomotives on the road, payments for overtime through delay, and disorganization of train service are so constantly before the management as to make the improvement of feed water a question of paramount importance. The problem, we know, is difficult, but for that very reason it is one that needs the closest and most careful study.

Tests made on freight locomotives in every-day traffic under speeds varying by 100 per cent. and loads varying by 33 per cent. seem to indicate a decided increase in ton-miles moved per pound of fuel when the speeds are high and the loads light. Trains of this character, while economizing in fuel, are wasteful as to wages; heavy trains at low speed decrease the wage expense per ton-mile enough to offset fuel increase and show besides some net economy. The indications are that the greatest economy in expenses directly proportioned to train movement should be attained with a heavily loaded train moving at moderate speed. Accurate data are desirable to show when the most economical speed and load are reached, because with present low rates and keen competition the margin between success and failure is extremely small.

To reduce the fuel bill, the following seem important:

a. Uniform fuel over the entire divisions with intelligent adaptation on each locomotive of the draught arrangements and grate bars to burn the given coal most economically; closely followed by a careful and systematic instruction of engineers and firemen.

b. Compounding locomotives where fuel and water are high-priced.

c. Improving locomotive boilers by providing larger grate areas and heating surfaces so that the maximum percentage of energy of combustion may be utilized.

Reducing the cost of handling coal to a minimum by providing power coaling plants is worthy of more attention than it has ever received.

Condemning light and poorly designed locomotives and substituting modern and well-designed equipment to a greater extent than is now done, due consideration being given in each design to traffic, fuel, and grade conditions, is an important line for effort.

We need closer inspection and prompter repair of locomotives at terminals so that they may always be sent out on the line in perfect condition and after the shortest delay. This, of course, means most careful and accurate reports from engineers of defects developed en route.

Closer study of the scrap pile, whose lessons are now too often unheeded, is earnestly recommended.

A vigorous effort to push designing, adopting and maintaining of standards, reducing the number of types of couplers, is greatly needed.

Widening and clearing the horizon of view of motive power officers and employes; leading them to recognize to a greater extent than they now do the conditions that determine the practice of keeping a locomotive on duty as long as possible after steam has been raised is important to commercial success. It has long been understood that car equipment must be kept moving to earn money: the principle applies with equal force to locomotive equipment. Some system of double crewing or pooling locomotives under present traffic conditions seems necessary. There are defects in, and objections to, the system, but motive power officers can render their companies lasting service by perfecting the system and removing or reducing the objections.

Finally, and perhaps above all, it is necessary to secure the loyal support of the entire motive power working staff from the highest to the lowest, in all measures that are prescribed by proper authority, cultivating the feeling that every man in his sphere is personally responsible for the success or failure of the department of the company in which he is employed.

APPRENTICES IN RAILROAD SHOPS.

By A. M. Waitt,

Superintendent Motive Power and Rolling Stock,

New York Central & Hudson River Railroad.

Inquiry made within a short time past develops the fact that up to the present time very little thought has been given to the subject of a systematic way of handling apprentices in railroad shops. In too many cases it would appear that the employment of apprentices had been done partly, at least, with the idea of getting labor at as low a rate of pay as possible, without considering the ultimate results of such a practice, and without considering the future welfare of the apprentice himself. In some large railroad shops a boy is taken in as an apprentice, and for about three to six months is used as a messenger, to run errands, and to sweep up around the shops. The next six months he is made use of on a bolt cutter or nut tapper, and then is put to drilling for a similar period, finally, after one and a half years of his four years' term has expired, a place is found for him on a lathe or a planer. In this place the young man perhaps develops considerable ability, and it is found that at his low apprentice's rate he is doing a certain class of work much cheaper than many full-fledged machinists, and it is considered by his over-zealous foreman a good piece of management to keep the boy on these tools as long as he can. Perhaps, after three or more years have gone by, the apprentice is allowed to help on the heavy lathe or planer, and he may possibly be sent for a while to do some brass work on the light lathes. After four years' time the apprentice is turned out a "journeyman," so-called, but in reality a one-sided mechanic, being able to do a few special classes of work well, and knowing little or nothing from practical experience of the many sides of the machinist's work that might help him to be more useful to his employers and himself.

I would urge the need of railroad companies making a special point of a systematic plan of apprenticeship. Whatever may be the ultimate line of special work which the young mechanic may take up, he is best fitted for it by being given a broad view of his field of opportunity. I believe that an apprentice in a machine shop, like an aspirant for honors in athletics, should be fully developed, and fully rounded out, and not made one-sided in his development.

In order to get the best results from an apprenticeship, a well-understood plan must be adopted, and all concerned must be held to strict account for carrying out in a broad sense the spirit and detail of the system. One foundation element is that all foremen, and those in charge of shop operations, should understand that apprentices are not taken with a view of simply getting as much work out of them at a low rate of pay as can be had, but rather with the intention of making them the

best all-around mechanics possible, having in view the benefits to be derived from their thorough instruction after they become fully qualified mechanics. Conditions in different shops vary so widely that no universal schedule of apprenticeship can be laid down. I will, however, suggest what seems to me to be a good schedule for apprentices in a large railroad machine shop. I will also make some suggestions regarding the working out of such a schedule, and some reasons why some peculiar features are introduced, and some other seeming essentials omitted.

Suggested Schedule and Instructions for Employment of Machinists' Apprentices in Locomotive Department Shops.

The course for regular apprentices will cover a term of four years:

First Year.	1 month in tool room.
	10 months in erecting shop, on both engine and tender work, including trucks.
	1 month on bolt cutter.
Second Year.	12 months machine work. Drills, one month; lathes, three months; planers, three months; slotters, two months; milling machines and boring mills, three months.
Third Year.	3 months air-brake work, including all parts of air-brake repairs.
	3 months brass work.
	6 months vise work, including rod and link work.
Fourth Year.	5 months heavy machine work, including tire lathe, quartering machine, heavy planer, etc.
	3 months firing on the road.
	4 months in erecting shop, including practice in valve setting.

No person is to be employed as an apprentice who is under seventeen (17) years old, or who is over twenty-one (21) years old.

No person is to be employed as an apprentice who has not had a good common school education.

In the selection of apprentices, other things being equal, preference will be given to the sons of faithful employees of the company.

At the end of the four years' term of apprenticeship, if the apprentice has proven faithful, and is a good workman, he will be paid on the basis of the minimum rate of wages paid mechanics in his class of work, and he will then be advanced from time to time, as the needs of the business and the merit of his services will permit.

No apprentices are to be employed without investigation first being made, as to their education, general character and apparent fitness for the work they desire to take up.

The heads of division shops must personally see and pass upon all candidates before they enter upon their apprenticeship.

If all the railroads would enter into this idea of systematic treatment of the apprentice question we should soon have a sufficient supply of well-trained young men ready at hand for the work which is every year becoming more exacting and requiring men of special training. It is becoming more and more difficult for young men to acquire the proper training as all-around workmen owing to the tendency toward specialization in every direction. It seems necessary, therefore, for us to attend to this ourselves. We should accept the lessen from some of the well-known machinery manufacturers who have for years considered the apprenticeship question as a vitally important part of their organization to the end that we shall have an available source from which to recruit the service with young men who have a pride in their calling because of their fitness for the work and because of their being the best men from whom to ultimately select foremen and officers of greater responsibility.

This cannot be accomplished by preparing specialists, but rather by supplying opportunities for an all-around development which may be used as a stepping stone to any of the specialties of which our work is full. With this in view the apprentice should be given the greatest possible variety of work in order to permit him to select wisely the specialty at the completion of the course, and also to give him as thorough an insight as possible into the operation of the department with special reference to the dovetailing together of its various parts. With this in view it is well that the apprentices should have the experience in firing. With this they not only obtain an excellent idea of the working of the locomotive and of its part in the operation of the road, but they also have another channel in which to direct their futures and another field in view when selecting their specialty after the completion of the course.

The reader will undoubtedly miss the drafting room in this schedule. It was left out for the reason that modern methods of operating the motive power department often require the chief drafting room to be located so as to be inaccessible to the shop forces and at the shops it is usually not necessary to provide more than a single draftsman at each of the more important plants. This renders it necessary to provide the instruction in drawing in some other way, whether this seems desirable or not, and this feature of the situation requires specially careful treatment. At most large railroad shop centers the Y. M. C. A. or the city provide evening classes, where good elementary instruction can be obtained in drafting. In localities where such instruction is available, and it is impracticable to send the apprentices of the railroad company into the drafting room, it would seem wise to make attendance at the night school, for instruction in drafting, compulsory for all apprentices.

It has been said, and it must be admitted to be a just criticism, that we devote our attention almost exclusively to the material of our profession, giving too small a proportion to the personnel, and from this fact has grown a situation in which the selection of properly qualified men for responsible positions is becoming more and more difficult.

THE MAINTENANCE OF AIR BRAKES ON FREIGHT CARS.

By G. W. Rhodes.

Assistant General Superintendent,

Burlington & Missouri River Railroad.

New equipment and material of all kinds generally must pass through a period of neglect and abuse on railroads before their full measure of advantage obtains. This is not confined to air brakes. We find the same thing in the maintenance of couplers, the use of oil, waste, the maintaining of parts on locomotives and cars, whose service depends almost entirely on the parts being intelligently bound together with properly secured bolts, nuts and keys. Even the compound locomotive has at times had a precarious existence largely because its machinery has not had the attention it requires. In the case of new machinery the cause for this is twofold.

First: When new parts, such as air brakes, are applied in large quantities to the equipment of a railroad, it is generally through the action of the higher officials who entrust the matter of maintenance entirely to their subordinates.

Second: Subordinate officers do not know what demands the new machinery is going to make on the facilities at their command and in too many instances proper maintenance, for lack of facilities and the difficulty in obtaining them, is not possible until there is a general agitation on the subject and railroad conservatism is overcome by well-established methods in more or less general practice.

A very important and necessary movement of this kind is now progressing in the matter of maintenance of freight car air brakes. At an enormous expense, the railroads in this country of late years have been equipping their freight cars with power brakes. How to keep them up is now a most important question. The subject has been well discussed and agitated by the Central Railway Club at its November, January and March meetings of 1900 and 1901.

We propose considering two features of this question:

First: What methods should obtain to insure the cleaning of triples at least once in every 12 months?

Second: Should there be few or many cleaning stations on a railroad or system of railroads?

In regard to the first question we believe a general acceptance of the fact that triple valves are apt to be out of order if they have not been taken apart and gone over at least once in 12 months will do much to bring about the necessary reform. The decision reached by some of the Western railroads in mountainous territories—that they cannot accept cars that have not had their triples cleaned within 12 months—is a move they are warranted in because of the extreme conditions that have to be met on their grades and curves. A knowledge of this fact by freight agents when they have secured a load of transcontinental freight in the East would do much to stir up the general question of triple valve cleaning, and two or three days' time in through California business can be saved in loading through freight at Pittsburg, Philadelphia, New York and other Eastern points if agents will insist on having cars furnished that have had their triple valves cleaned within 6 months. The joint inspection at Denver is very rigid on this matter and the switching incident to a rejected car easily covers 3 days, if not more. If a railroad, owing to short mileage, had 3 days the advantage of a competing line in coast business, it would not fail to let this be known in soliciting freight. Here is an opportunity to get the same result by intelligent loading on the part of shippers. Some wide-awake roads are already availing themselves of this information.

The most important and effectual method of cleaning triples in the opinion of the writer is to keep a monthly record of the number cleaned and have this statement placed on the desk of the official who is responsible for their proper maintenance. To attempt such work without a record will never bring about the desired results. It will be a good deal like the light weights of cars whereby, through the neglect of the railroads of this country, thousands of dollars are lost every year. The chief reason for this neglect is that few railroads keep a monthly record of cars light-weighed at weighing stations and therefore they never know when any given weighing station is weighing all the cars it can or only a part. After a discussion on the importance of light weighing freight cars recently at a foremen's meeting on the Burlington road, notwithstanding the fact that no monthly tabulation of light-weighed cars have yet been made, an important weighing station increased its number of light weighings from 60 cars a week to 500!

A clear and comprehensive method of monthly triple-valve cleaning record is that described and practiced by Master Car Builder Canfield, of the D., L. & W. Railroad, which will be found in the March issue of the proceedings of the Central Railway Club. We have plenty of rules: the question is how to enforce them. Nothing is so effective as a monthly record intelligently compiled and looked after.

Let us now briefly consider the question of whether there should be few or many cleaning stations. This must depend largely on local conditions. On a line like the Burlington we favor not less than one general cleaning point on each superintendent's division, located preferably at the division shop headquarters, and in order that triple valves may be cleaned once in every 12 months we believe valve cleaners should have instructions to clean triples that have not been cleaned within 6 months and upward. Recently, in taking exception at one of our shops to the fact that they were not cleaning enough triples monthly, the Master Mechanic told me they could not clean any more even if they had more force and facilities, for they only cleaned the triples having 12 months and over of service; 10-month triples and 11-month triples were not touched. In axle limitations we have a shop limit which differs from the road limit, and it is believed the 12-month limitations for triples will be more nearly maintained if men at cleaning points are instructed to overhaul everything that has not been cleaned for six months or over. We do not favor a central cleaning point for the reason that some cars may never reach the general point, and to remove and exchange triples other than on divisions of limited length would necessitate carrying in stock many extra triples, as well as causing delays incident to shipping. Moreover, a little competition incident to many cleaning and repairing stations has a very healthy influence in maintaining the character of the work.

These cleaning and repairing stations should be thoroughly equipped with all appliances to quickly and expeditiously do the work required, including compressed air appliances, so that after repairing or cleaning each triple may be subjected to the M. C. B. single valve test. One of the best of such cleaning stations is the one located at Western avenue, Chicago, on the C., B. & Q. Railroad. This repair shop with one man can average 3 triple valves overhauled and tested per hour or 30 per day of 10 hours.

In conclusion, to properly maintain triple valves, we advocate:

1. A road limit of 12 months.
2. A shop limit of 6 months.
3. A central cleaning station properly equipped with compressed air and triple valve cleaning and testing appliances.
4. A monthly record showing the proportion of triple valves cleaned and overhauled to the number of air braked cars owned.

ECONOMICAL TRAIN SPEEDS.

From the Fuel Standpoint.

By G. R. Henderson,

Assistant Superintendent Motive Power,
Chicago & Northwestern Railway.

Much interest has been manifested recently regarding the effect of speed of trains upon cost of operation, and particularly upon the question of fuel consumption. Numerous theoretical deductions and guesses, more or less wild, have been made as to the law of coal consumption relative to speed, but the writer believes that he was the first to make a practical demonstration of the rule of increase by means of a series of experiments with a good-sized freight locomotive. The tests were made on the "Test Plant" of the Chicago & Northwestern Railway Company at Chicago, and on the road by means of the dynamometer car belonging to the same company.

A brief account of the results of the test plant experiments was given in the American Engineer and Railroad Journal of June, 1900 (page 186), but the road tests not having been at that time undertaken, the diagrams could not be made complete. These have since been made, however, and a set of new diagrams worked up by the writer combining the results of both methods of procedure, and which, it is believed, place the results in a more convenient shape for examination and use.

As stated in the previous article, the tests were made with the standard Class R ten-wheel freight locomotive of the Chicago & Northwestern Railway, illustrated in the American Engineer and Railroad Journal in December, 1897, page 407, the principal dimensions of which are as follows:

Principal Dimensions of Class R Locomotive.
Chicago & Northwestern Railway.

Cylinders	20 ins. by 26 ins.
Driving wheels, diameter	63 ins.
Steam pressure	190 lbs.
Boiler diameter	64 ins.
Grate area	29 sq. ft.
Heating surface	2,332 sq. ft.
Weight on drivers	118,350 lbs.
Weight of engine and tender	260,000 lbs.
Steam ports	1⅝ by 16 ins.
Exhaust ports	3 by 16 ins.
Valve	Allen-American balanced
Outside lap	⅞ in.
Inside lap	Line and line
Valve travel	5½ ins.
Lead at 6-inch cut-off	¼ in.

Referring now to the diagrams, No. 1 illustrates the fuel consumption at various speeds and expansions. These results were obtained by running the locomotive upon the test plant and carefully weighing the coal and measuring the water used while the engine was running for a period of considerable length at fixed speeds and cut-offs. The coal was all weighed

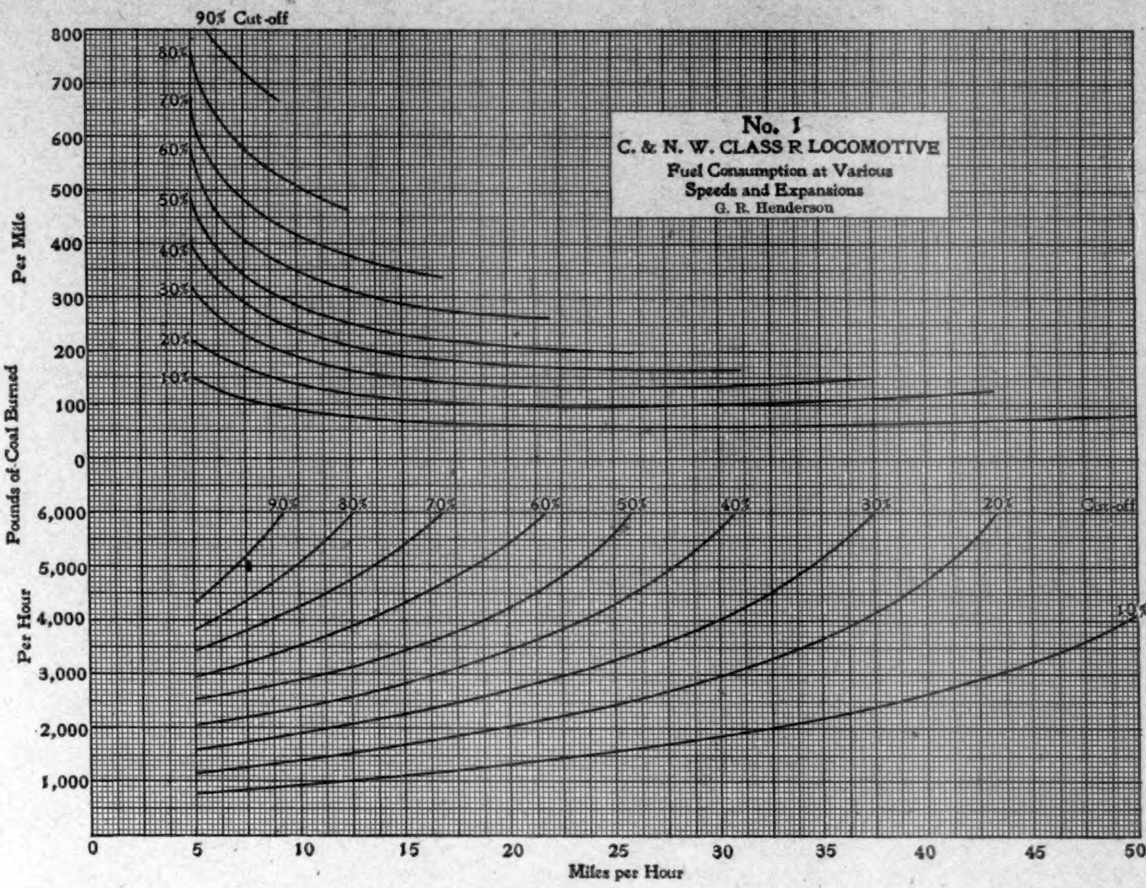

Diagram No. 1.

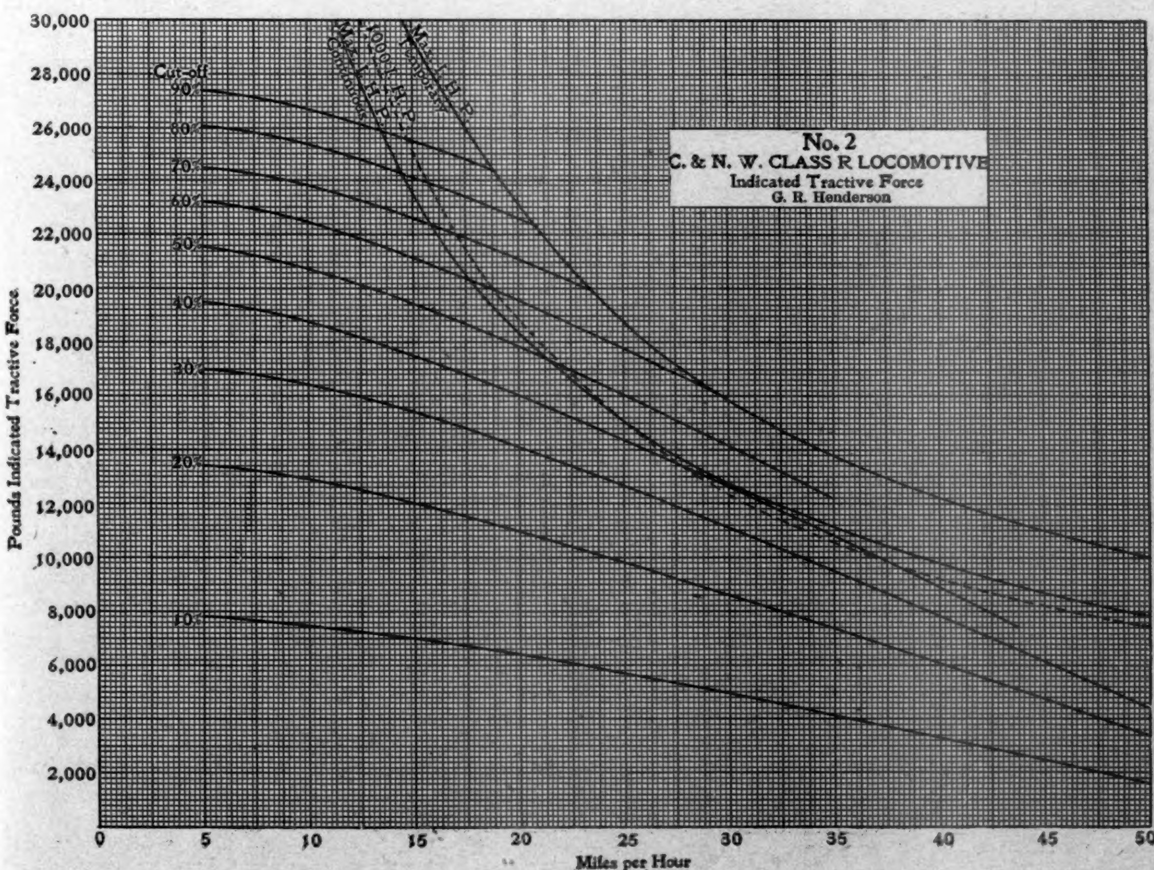

Diagram No. 2.

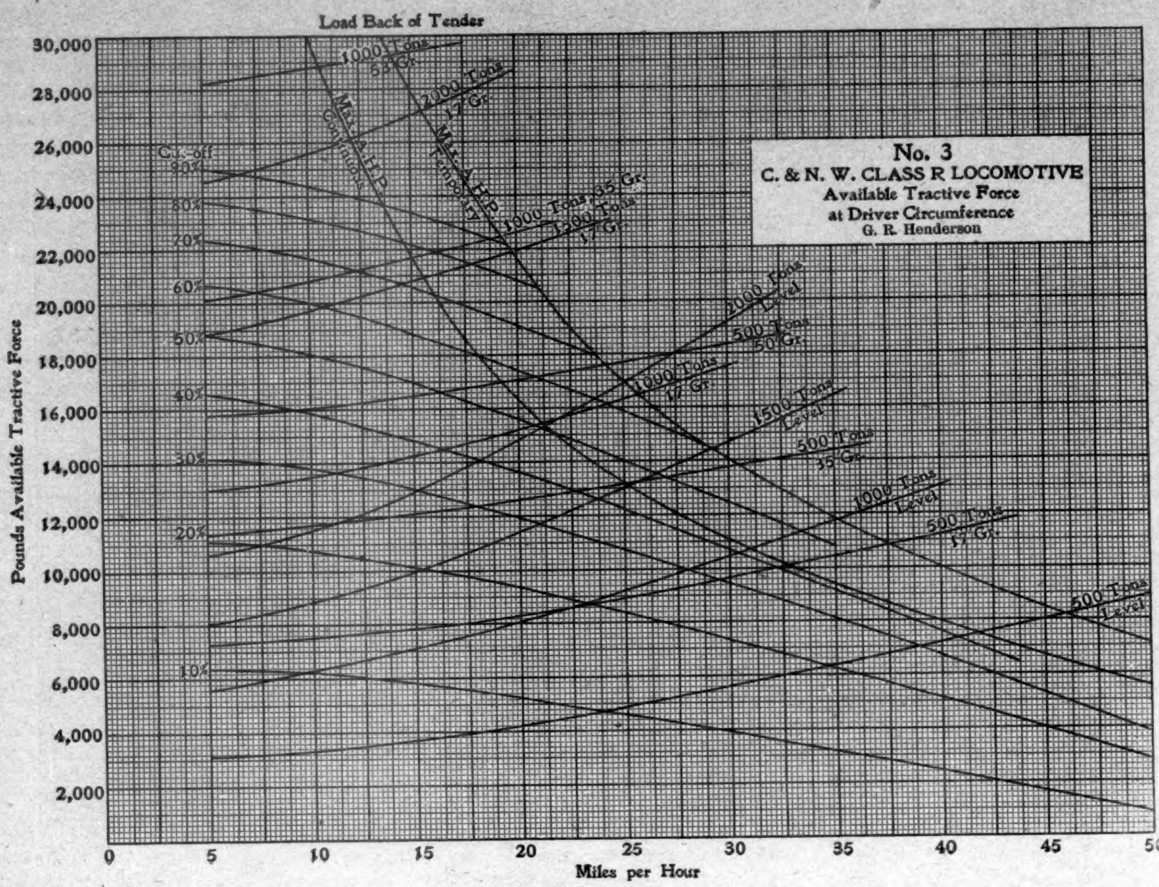

Diagram No. 3.

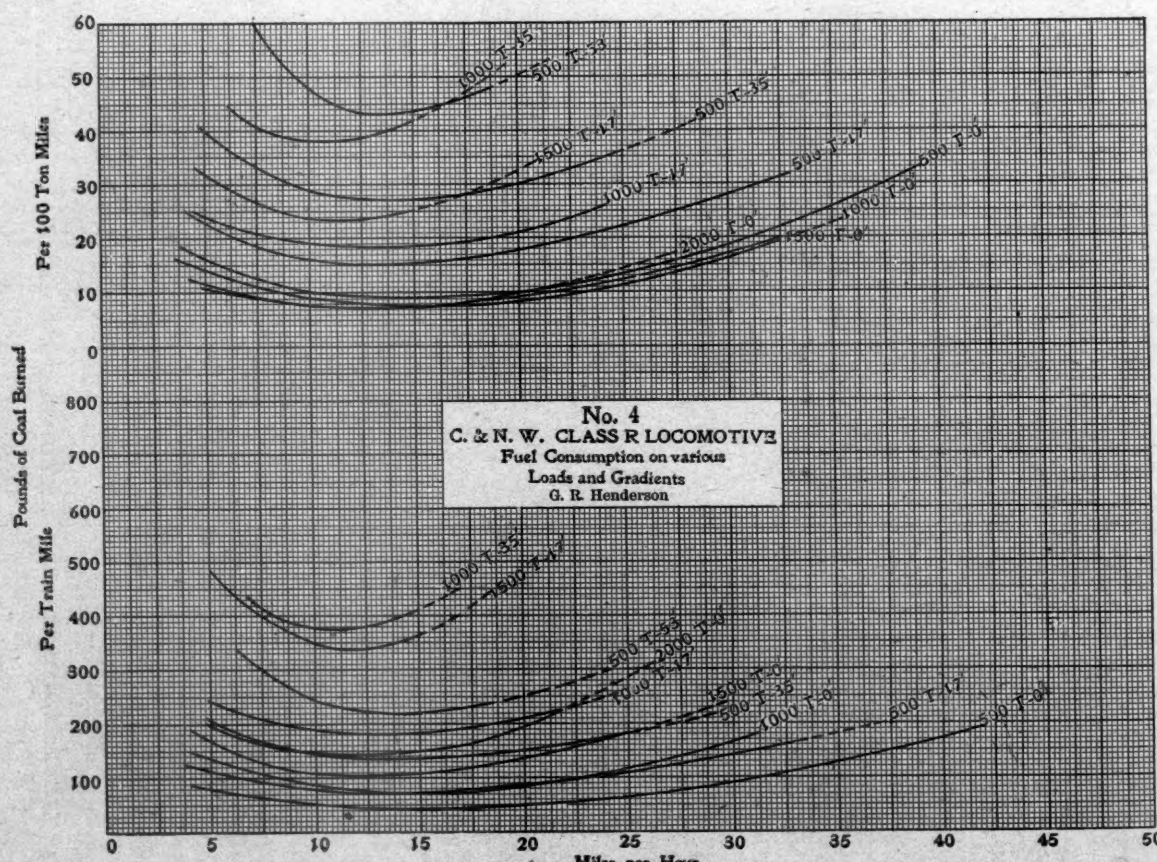

Diagram No. 4.

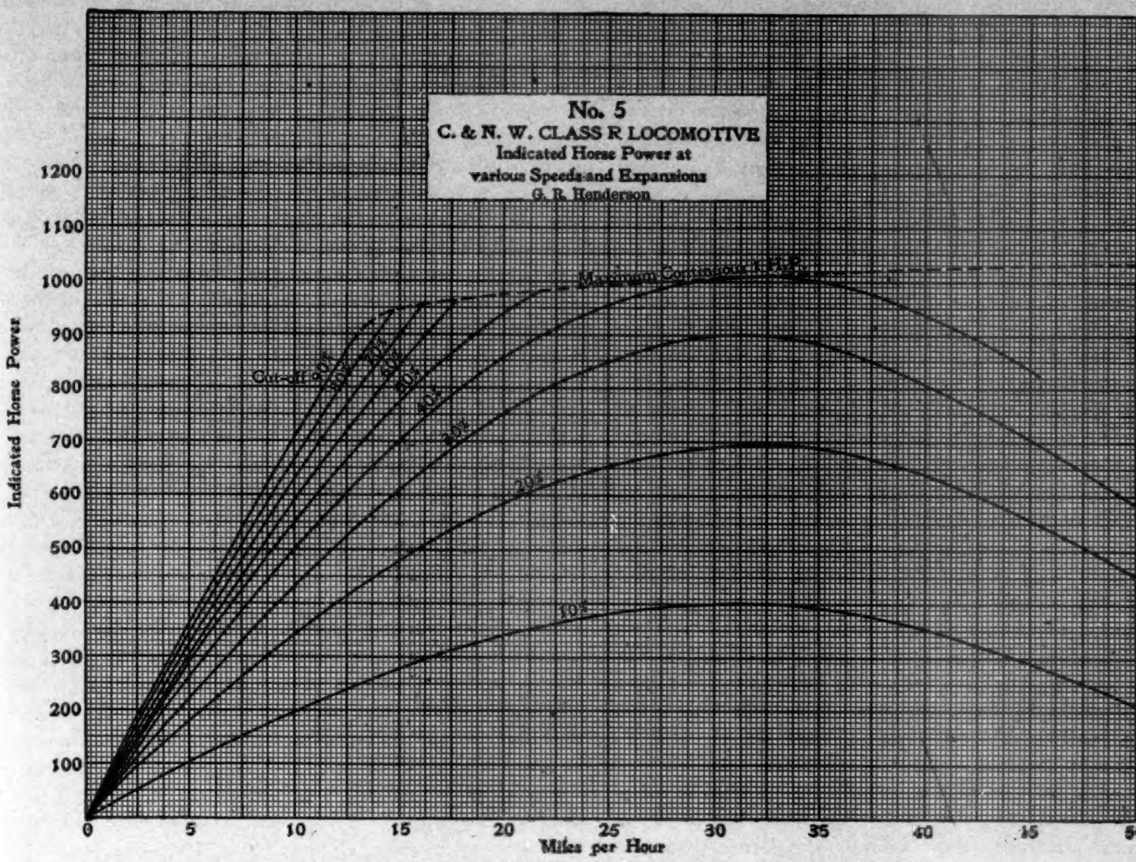

Diagram No. 5.

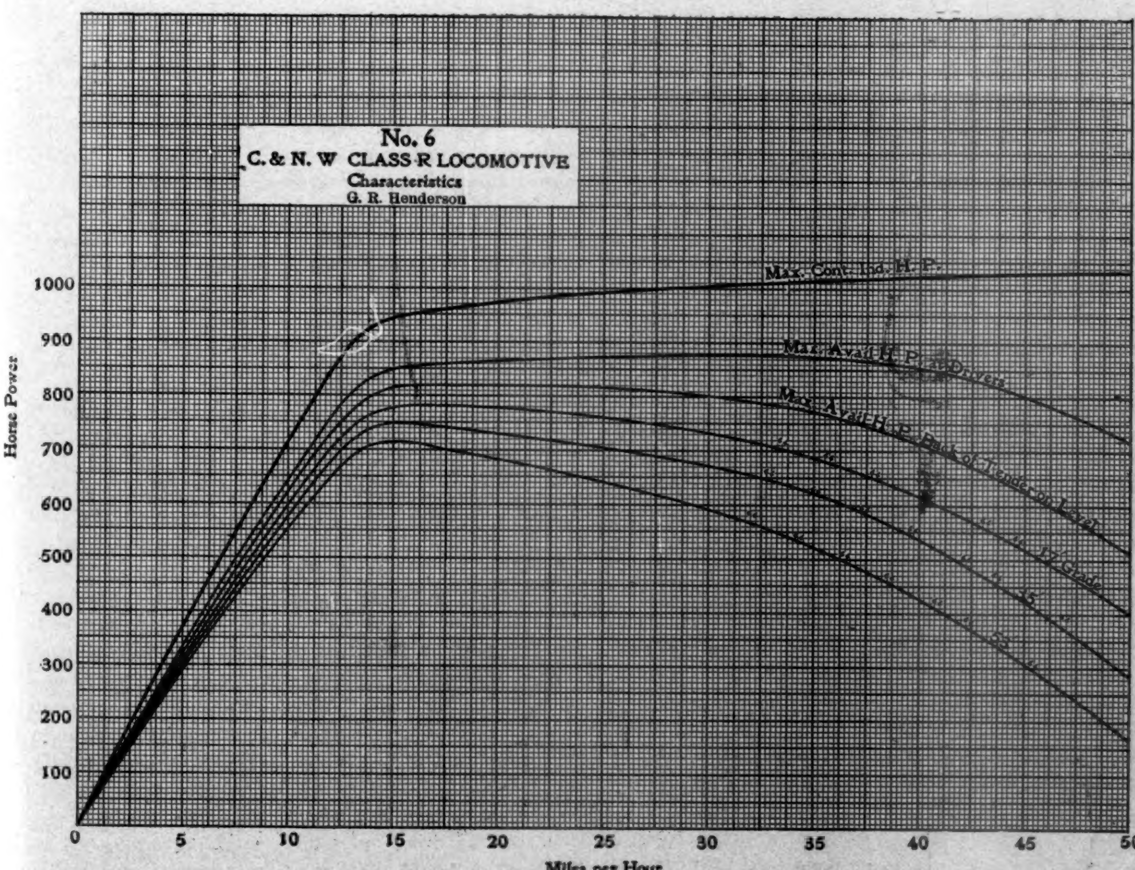

Diagram No. 6.

in a wheel-barrow just before being dumped upon the foot plate of the engine, and the water was passed through measuring tanks, carefully calibrated. A full throttle and maximum boiler pressure were maintained. The tests were run in regular series, and the results were laid off by points on cross ruled paper, and connected and interpolated to give the curves shown. From the care with which the tests were conducted, the writer feels that the results are what might be termed "commercially accurate."

The lower set of curves represents the pounds of coal consumed per hour under the different conditions. In all these diagrams the speed is shown by the abscissae. It will be noticed that 6,000 lbs. per hour was the maximum amount of fuel which it was possible to burn; this was a trifle over 200 lbs. per square foot of grate surface. The abscissa corresponding to the limit of the various curves at 6,000 lbs. denotes approximately the maximum speed which could be maintained by the boiler at the different expansions, although this is shown better on another diagram.

The upper set of curves gives the consumption per mile run, and was constructed from the lower set by dividing the several values by the speed during the test. It will be noticed that from 5 to 15 miles per hour the amount of fuel per mile decreases, but above 15 miles an hour, the quantity per mile is nearly constant at the same cut-off.

Diagram No. 2 gives the indicated tractive force for different speeds and cut-offs. These curves were worked up from the indicator cards taken on the test plant and with the dynamometer car in road service. The line marked "Max. I. H. P. Continuous" shows the maximum horse-power or tractive force which can be maintained continuously by the locomotive. It will be seen that this follows closely to the 1,000 horse-power curve, which is what would be expected from the 2,332 ft. of heating surface in the boiler, allowing 2.3 sq. ft. of heating surface per horse-power.

The line marked "Max. I. H. P. Temporary" denotes horse-power 25 per cent. in excess of the continuous horse-power line, and shows what might be obtained for a short period by closing off the injectors, thus taking advantage of the supply of heated water in the boiler, as the amount of heat used in raising cold water to the boiler temperature and pressure is about one-fourth of the total heat of evaporation under the existing conditions. It will be understood, therefore, that the latter line shows the limit which could be reached, but maintained only for a short time.

Diagram No. 3 was computed from diagram No. 2 by deducting from the indicated values the amount of internal resistance of the engine. This ranged from 8 per cent. with long cut-off to about 15 per cent. at short cut-off, and was derived from the dynamometer car test by allowing for the resistance of the engine and tender on the grade and at the speed at which the test was made. These resistances were added to the recorded drawbar pull and this was considered to be the available tractive force at the circumference of the drivers, and the curves were laid out to represent these values. The maximum available horse-power curves have the same meaning as in diagram No. 2.

The additional curves on diagram No. 3 indicate the resistance of trains of 500, 1,000, 1,500 and 2,000 tons back of the tender, on grades of 0, 17, 35 and 53 ft. to the mile. The calculations were made to include the weight of engine and tender in the resistance, so that the curves are directly comparable with the available tractive force curves. The intersection of these lines with the tractive force curves indicates what cut-off it is necessary to maintain to operate the desired trains at the designated speed. They also show the maximum conditions, and such as are beyond the power of the engine to handle.

For example, let us consider a train of 1,000 tons back of the tender on a 17-ft. grade. To operate at 10 miles an hour would require 30 per cent. cut-off; at 15 miles an hour, 40 per cent. cut-off; and at 20 miles per hour, 50 per cent. cut-off. This would be the limit of continuous operation, but for a short distance it could make 25 miles per hour at 60 per cent. cut-off. No higher speed could be obtained with this load. These, of course, are for dead pulls, and not momentum runs. For 1,500 tons on the same grade and at speeds of 5, 10, 15 and 20 miles per hour the cut-off would be 50, 60, 70 and 90 per cent. respectively. The latter would be the limit of speed. We also can see, from the intersection of the train curves, that 1,500 tons on the level calls for the same work at 25 miles per hour as 500 tons on a 35-ft. grade; above this speed more, and below it, less power is required.

Diagram No. 4 has been constructed by combining the results shown on diagrams Nos. 1 and 3, by taking the amounts of coal needed for the conditions necessitated by the various train-loads and speeds. The lower group of curves gives the amount of coal necessary per train mile. The upper group indicates the consumption in pounds of coal per 100 ton-miles and was figured from the lower group by dividing by the weight of the train. The train weights are considered as those back of the tender. This diagram illustrates the increase in coal following an increase in speed. For instance, on a level, the amount of coal consumed per 100 ton-miles should be about 7 lbs. at 15 miles an hour, about 8 lbs. at 20 miles, 12 lbs. at 25 miles and 17 lbs. at 30 miles an hour. Thus it appears that doubling the speed more than doubles the coal consumption, when starting at 15 miles speed. It will be noticed that the minimum consumption for the various loads and grades lies between 10 and 15 miles per hour, and that the ascending portions of the curves are nearly parallel to each other, which may be interpreted as meaning that the increase in consumption due to speed is nearly the same for the various grades. There is a greater increase, however on the heavier grades. From 10 to 15 miles an hour should, therefore, be the most economical speed, as far as fuel is concerned. These tests were made in freight service, it should be remembered, but it is not clear why passenger engines would not follow a similar law. This demonstrates that it is inaccurate to compare the coal consumption of different trains without taking into consideration the speeds at which they are run.

Diagram No. 5 shows the indicated horse-power under different conditions of expansion and speed. At low speeds the horse-power increases nearly directly as the velocity, but with higher speeds the curves droop. Thirty miles per hour gives the maximum powers, and the explanation of this is that at higher speeds the steam does not have opportunity to enter the cylinder rapidly enough to maintain the mean effective pressure. The line marked "Maximum Continuous I. H. P." denotes the limit of boiler capacity.

Diagram No. 6 gives a set of "characteristics" for the Class R engine. The upper curve is the same as the one just described. The second curve gives the maximum available horse-power at the drivers, and has been produced by deducting the internal resistance of the engine from the first curve. The third has had the "rolling resistance" of the engine and tender subtracted and therefore gives a measure of power at the tender coupler. The curves for the different grades were located by further deducting the power necessary to overcome the force of gravity for the weight of the engine and tender. The last four might be termed "commercial characteristics," as they give an index of the useful work performed.

It is interesting to note that the maximum for this set is at 15 miles per hour. We would therefore conclude that this speed, 15 miles, not only is the most economical in regard to fuel consumption, but also represents the velocity at which the greatest amount of useful work can be gotten out of the engine, or where the maximum power is utilized.

Of course other questions, such as wages of train crews, interest and depreciation on equipment, etc., will modify the question of total speed economics, but it is felt that the fuel and power part of the problem will be made clearer by the graphical demonstration accompanying this study.

NEW VENTILATING SYSTEM FOR PASSENGER CARS.

PENNSYLVANIA RAILROAD.

In the June, 1900, issue of this journal, page 191, an article was published on the ventilation of passenger cars in which was discussed the conditions surrounding the problem. It will, perhaps, be remembered, that it was thought that in a successful system of passenger car ventilation the heating system is an essential feature; that it is desirable that the system should be operative both summer and winter, and that in the present state of our knowledge as to what constitutes good ventilation, 60,000 cu. ft. of fresh air per car per hour, or about 1,000 cu. ft. per passenger per hour, is, all things considered, the most suitable figure to work to in developing a system.

The object of the present article, which has been prepared with the consent of the management of the Pennsylvania Railroad Company, is to describe with considerable detail the system which, as the result of several years' study, has been worked out on that road, which was put on trial on five cars considerably over two years ago, and which has at the present time been applied to a little over 200 cars.

As will be observed from an inspection of the general plan accompanying, Fig. 1, the system in its outline is very simple. It consists in taking air from the outside in through two hoods at diagonally opposite corners of the car, thence through the down-takes underneath the hoods to the spaces, one on each side underneath the car floor, bounded by the floor, the false bottom, the outside sill, and nearest intermediate sill. These spaces, which are in section about 14 by 7½ ins., extend the whole length of the car. From these spaces the air passes up through the floor by means of proper apertures, over the heating system and thence out into the car, and finally escapes from the car through ventilators situated on the center line of the upper deck.

The hood construction is shown in Fig. 2. It will be noted that a wire gauze covers the two faces of each hood, the object being to exclude cinders of any appreciable size, especially such as might lead to incipient fires. The flap valves shown are so manipulated that the air has a free passage into the down-takes from the direction in which the car is moving. These valves are controlled by a mechanism operated by the trainmen inside the car, the little crank on the operating device indicating the direction in which the valve should be open. The doors in the down-takes permit the operating devices for the flap valves to be connected, and also allows a chance for inspection. It is interesting to note the strong downward current of air when these doors are opened for a moment, while a car is in motion. The down-takes have each an area of about 100 sq. ins. In the down-take just below the mechanism operating the flap valve is a butterfly valve, by means of which it is possible to very nearly close the down-take. The normal position of this valve is open, the trainmen being instructed to close it only when going through tunnels, or when standing in stations with the locomotive detached, when it is desired to keep heat in the car as long as possible. The funnel-shaped cavity at the bottom of the down-take with a hole in it, allows cinders which pass the gauze to escape from the car. Thus far no difficulty has been experienced from large accumulations of fine cinders, either at the bottom of the down-take or in the air passage connected with it. There are some indications that fine cinders will collect in the conduit between the sills, and this point may need further study. In most passenger cars the sills are connected together at short intervals by cross bracing. In order to form the air passage or conduit between the outside sill and the nearest intermediate as above described, it is necessary to remove this cross bracing. In place of it, in order not to weaken the car structure, braces of iron are used in the form of open frames. These allow a free passage for the air and being bolted to the sills

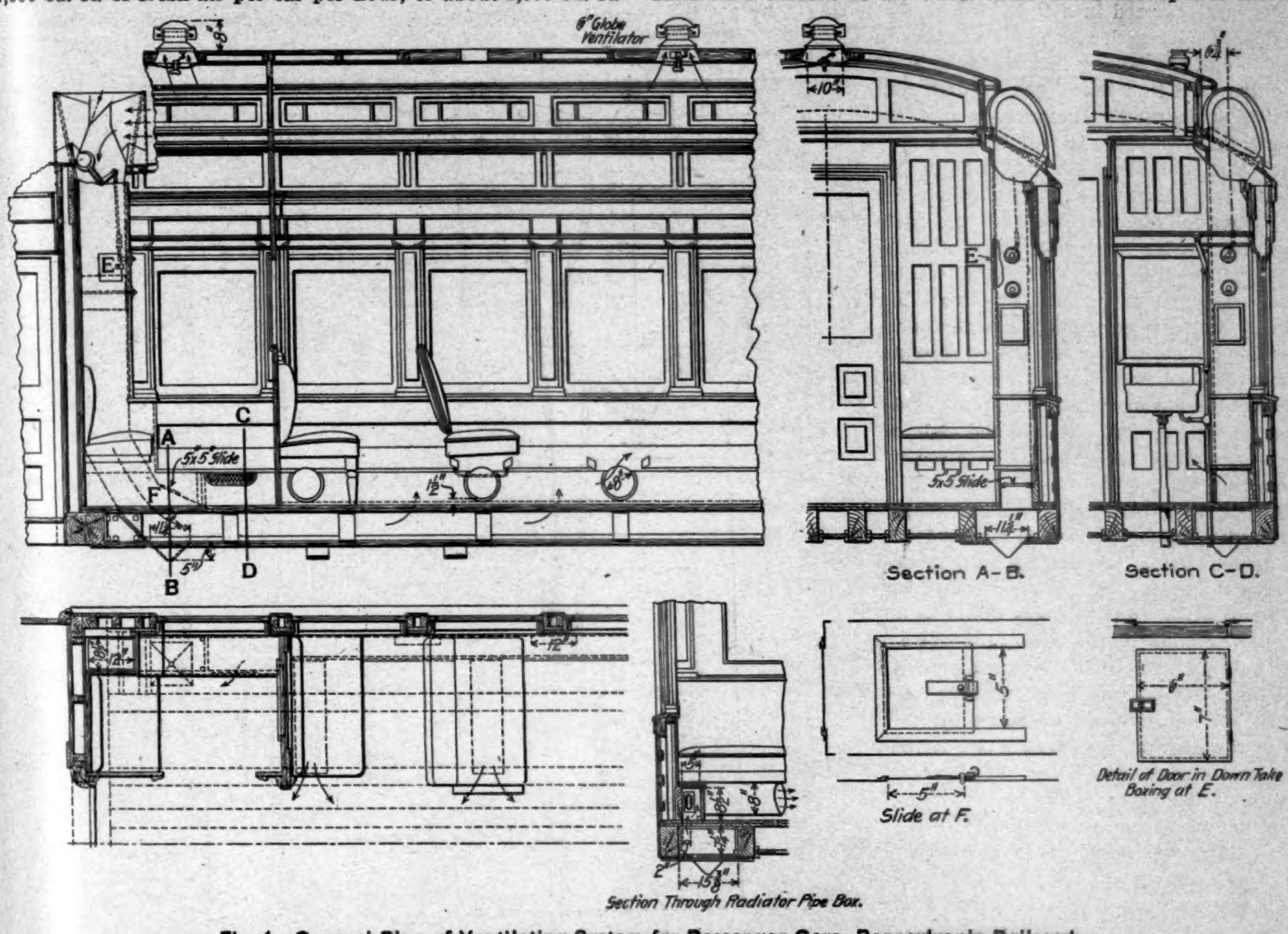

Fig. 1.—General Plan of Ventilating System for Passenger Cars—Pennsylvania Railroad.

are believed to strengthen the car rather than weaken it.

The apertures in the floor are made by cutting slots 2 by 12 ins. through the floor itself. There is one of these slots between each two seats on both sides of the car. In the early stages of the experimental work it was thought that it might be essential to make the slot through the car floor continuous, but a little experience showed that this was unnecessary. The heating system consists of continuous radiators, rectangular in shape as is seen, fitted with fins to increase radiating surface and extends nearly the whole length of the car on each side. Under each seat is a Bundy loop attached to the main radiator, and forming a part of the heating system. These radiators, with the small steam pipes which supply them, are enclosed in a tight continuous boxing 5 by 8½ ins. inside. Under each seat is an aperture in the side of the boxing into which is fitted a galvanized iron tube 8 ins. in diameter, which encloses the Bundy loop and extends to the aisle. It will thus be seen that the cold air from the conduit between the sills is taken up through the apertures in the floor between the seats into the boxing enclosing the radiators. Here it comes in contact with the radiators, and must move each way from the slot in the floor horizontally, to the apertures underneath the seats, thence through the galvanized iron tube, receiving an additional increment of heat from the Bundy loop on its passage, out into the aisle of the car. From these points it disseminates through the car.

During the experimental work attempts were made to take the heated air out from the heater boxing, through registers in the sides of the boxing, into the space between each two seats. But this was found to be so objectionable to the passenger sitting next to the window that it was abandoned. Also an attempt was made to take the heated air out through apertures in the top of the boxing between each two seats, the idea being to have a current of warm air direct from the radiators pass up along the windows to neutralize their chilling effect. But it was found that this aperture served as a convenient receptable for materials thrown in by the passengers. Still further, during the experimental work, the slots in the car floor were made 4 ins. long and spaced 4 ins. apart, and the radiators were fitted with tin shields so arranged as to keep the air in contact with the radiators as long as possible, but none of these devices worked as well as the arrangement finally adopted. The total radiating surface of the heating system is 247.24 sq. ft.

The control of the ventilating system—that is, the devices by which the amount of air taken into the car is increased or diminished—is in the ventilators situated along the center line of the upper deck. The ventilators thus far used are of the type known as the Globe ventilator, and there are six of them of the 6-in. size. They are spaced one at each end and one between each two of the five lamps. Of course the lamp ventilators also remove some air, and as these ventilators have 6-in. tubes, it was soon found that the lamp ventilators in connection with the Globe ventilators removed more air than the heating system would properly warm in severe weather; also that with the Globe ventilators closed, nearly the limit on which the system was planned, viz., 60,000 cu. ft. of fresh air per hour, would pass through the car, thus leaving the ventilating system without any control. Accordingly the lamp ventilators were partially closed by inserting diaphragms in them, leaving only a 2-in. diameter aperture for the escape of the lamp gases. This point will be referred to later.

The Globe ventilator and damper are shown in Fig. 3. It will not escape attention that the Globe ventilators may all be completely closed, except for some small leakages, or may be partly closed, or part of them may be closed and part left open, thus giving very great flexibility to the system. It will also not escape notice that thus far no reference has been made to the movable deck sash which are in so many cars, such an important element in the ventilation of the car. Upon this point it may be said that in the system of ventilation which we are describing the movable deck sash has no place. The deck sash are purposely made tight and immovable, with no deteriment to the ventilation, and with very gratifying improvement in the behavior of the car lamps. Lamps which formerly gave much difficulty due to cross drafts between open deck sash can be used with very satisfactory results in cars fitted with the new ventilating system. A further marked advantage of fixed deck sash is the entire absence of cold air currents falling on the heads of the passengers, which is so unpleasant a feature of the movable deck sash. This point alone is no small item in favor of the new system, and when it is remembered that no cinders can come in through the fixed deck sash, it seems evident that the concomitant advantages of the methods adopted in this system are not inconsiderable.

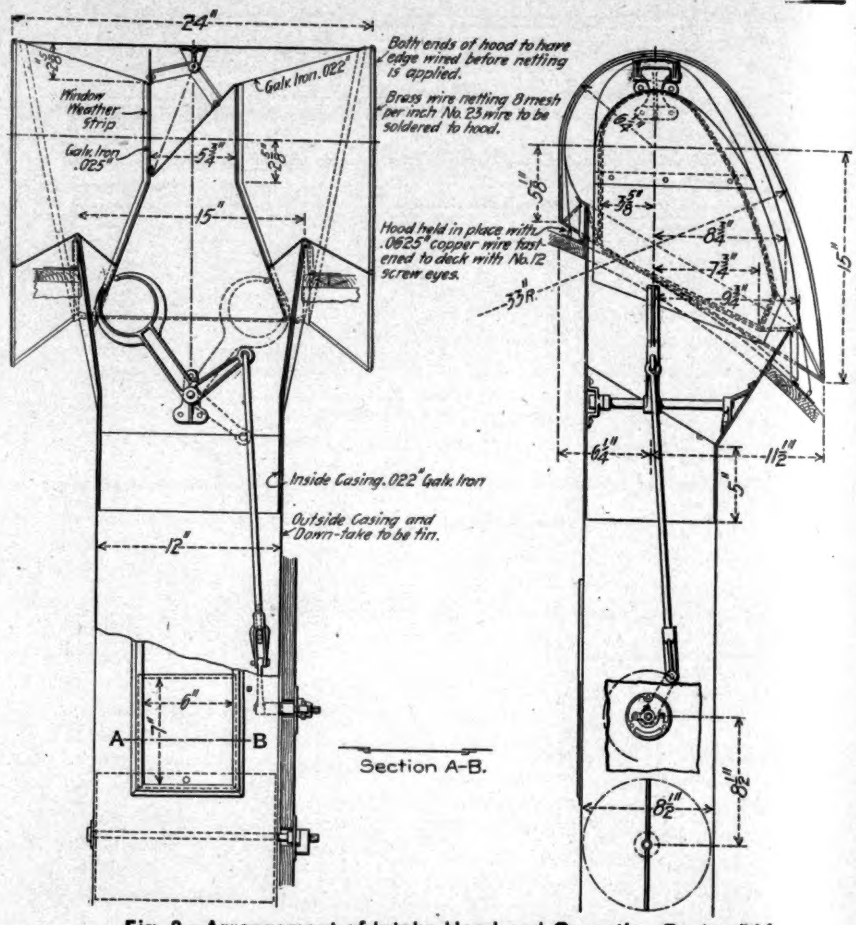

Fig. 2.—Arrangement of Intake Hood and Operating Device.

The experimental work having led up to the construction above described, it remained to test the system and see what results it would give. The first tests were made to demonstrate whether the air currents would flow in the direction desired when the car is standing still. It is well known that some ventilating systems depend for the proper movement of the ventilating air currents on the movement of the car itself, and that when the car is standing still the ventilating air currents move in the wrong direction. In the system above described this difficulty, however, does not occur. It is of course fair to be said that when there is no heat in the car, and when the lamps are not lighted, there is very little movement of the ventilating air currents in either direction when the car is standing still; but definite experiments clearly show that when

there is heat in the car or when the lamps are lighted the ventilating air currents move in the direction desired. This is easily seen by holding smoking waste at the ventilators, and also, as above mentioned, by observing the motion of the air in the down-takes through the opened door. It is not difficult to see why this should be so, since the exits from the Globe ventilators are nearly 2 ft. higher than the top of the hood at which the air enters. It may not be amiss to mention that when a car has been closed and standing on a siding for some time during very cold weather and is then put in a train and given heat, there is a little difficulty in getting the air currents started in the right direction. This is due to the fact that the column of cold air between the car floor and the tops of the ventilators is longer than the column of cold air from the bottom of the air conduit between the sills to the top of the hood. The difficulty is readily overcome by opening the car doors for a few minutes and allowing the cold air to pass out.

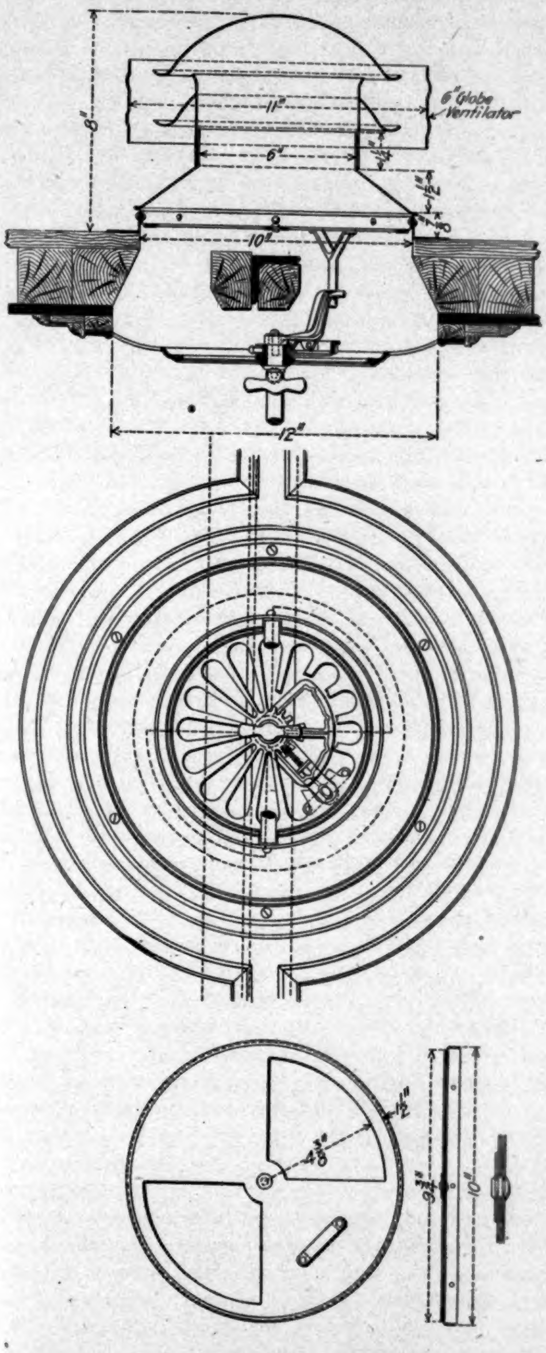

Fig. 3.–Globe Ventilator and Damper.

Another point which caused some anxiety during the development of the system was soon put to test. It is well known that the construction of the Globe ventilator is such that when moving through the air on top of a car or when the wind blows past the ventilator, a suction is produced in the ventilator tube. This behavior of the Globe ventilator is one of the items relied on to cause the proper amount of ventilating air to pass through the car when in service. Moreover, the hood, when the car is in motion, acts as an injector and forces air into the car. Now it is obvious that if the exhausting action of the ventilators is in excess, there will be a slight vacuum in the car; on the other hand, if the injecting action of the hood is in excess, there will be a slight plenum in the car. In the experimental work every effort was made to secure a plenum in the car. But limitations of space inside the car, and clearances outside, rendered the efforts in this direction not quite as successful as could be desired.

It should be mentioned that experiments demonstrating whether a plenum or a vacuum exists in a car at any moment, are difficult to make, and are more or less unsatisfactory at best, and although some time has been spent over this point and a number of experiments made, the question of a plenum or a vacuum is not yet fully settled. The best that can be said is that there is no strong evidence that when the system is in normal operation there is a plenum. The tests indicate very closely a balance with a slight preponderance toward a vacuum. Such being the case, it would naturally be expected that cold air current would flow in through every available crack or crevice, and especially that contaminated air would be drawn from the closet into the body of the car. In actual practice it is found that the difficulties from cold air currents through cracks and crevices are so small as to be ignorable. The possibility of contaminated air from the closets gave more anxiety, and as a precautionary measure a 4-in. Globe ventilator was put in the roof of each closet. With this construction and with the close balance between plenum and vacuum in the car as above stated, no difficulty whatever has been experienced due to contaminated air from the closets. Indeed many and oft-repeated tests show that when the car is in motion the actual air movement is toward the closet rather than from it.

The above preliminary tests having been made, it became interesting and essential to know positively what the system would do in the way of furnishing fresh air to the cars. In order to decide this question a car fitted exactly as above described was filled with men from the shops, who were paid for their time, under the charge of a foreman so that they could be controlled in the matter of opening doors and windows and a trip was made early in December, from Altoona to Johnstown and return. Rubber bags and hand bellows were taken along with which to secure samples of the air in the car. Steam heat was necessary since the temperature outside was from 23 to 30 degs. Fahr., and neither door nor window was opened during the trip, except that after the proper samples of air had been taken at Johnstown the men were allowed some freedom, since a wait of a couple of hours must ensue before the return trip could be made. The air samples for analysis were taken by pumping air into the rubber bags by means of the hand bellows, moving from one end of the car and back again in the aisle during the operation, and taken the air from about the level of the heads of the passengers. The analyses were made immediately after the return and always the same day.

It is fair to say that during the development of the system this same trip was made a number of times, as successive modifications were tried, and during the study on this subject probably not less than thirty to forty tests of the air from cars have been made in the laboratory of the Pennsylvania Railroad Company. The final tests only are given below. In making the air analyses the carbonic acid only was determined, and from this was calculated the amount of fresh air taken through the car per hour by the ventilating system, the method used being the one described in the paper referred to in the beginning

of this article. The figures obtained on the trip mentioned are as follows:

	Per cent. of Carbonic Acid.	Cubic Feet of Air Per Car Per Hour.
West Bound.		
All Globe Ventilators closed, Bennington.......	0.18	26,728
All Globe Ventilators open, Buttermilk Falls...	0.10	62,400
All Globe Ventilators open, standing 20 minutes at Johnstown..................................	0.21	22,996
East Bound.		
All Globe Ventilators closed, Cresson............	0.14	37,440
All Globe Ventilators open, McGarvey..........	0.10	62,400
All Globe Ventilators open, standing 20 minutes at Altoona................................	0.20	23.400

In explanation of the figures it may be stated that the stations mentioned denote locations at which air samples were taken. Bennington, on the schedule used, is about 23 minutes from Altoona; Buttermilk Falls is about 57 minutes from Bennington, and Johnstown is about 10 minutes from Buttermilk Falls. Returning, Cresson is about 42 minutes from Johnstown; McGarvey about 20 minutes from Cresson, and Altoona about 5 minutes from McGarvey. These figures will give some idea of the interval between samples.

As has already been stated, the system was designed to supply 60,000 cu. ft. of fresh air per hour to a car, and it will be noted that when all the Globe ventilators were open, that is when the system was working normally as designed, the actual amount of fresh air obtained, was a trifle above the desired figure, as is shown by the samples taken at Buttermilk Falls and McGarvey. It should be stated that the actual amount of air supplied from time to time is affected by several conditions. The speed of the train has an influence, also the differences in temperature inside and outside of the car, and the direction and force of the wind. Just how much each of these variables amounts to is not known. It would require a number of tests under each of the varying conditions to decide these points definitely, but as the west-bound schedules was a slow one and the east-bound a more rapid one, it seems fair to assume that the system fulfils the requirements for which it was designed fairly well. It is also interesting to note that when the Globe ventilators were closed; that is, when the designed control was applied, the amount of air supplied was cut down approximately one-half, as is shown by the samples taken at Bennington and Cresson. In other words, the control makes it possible to reduce the amount of fresh air when it is desired to do so, as for example when there are few passengers in a car, or perchance in extreme cold weather, when the heating system may not be quite sufficient to warm the full amount. Finally, the samples taken at Johnstown and Altoona show what the system does, when a car is standing on the track, as at stations en route. It would, of course, not be expected that the same efficiency would be shown when the car is at rest as when it is in motion, and indeed this hardly seems essential. It will not escape notice that the difference between the amount of air supplied standing still and when the train is in motion, measures the effect of the movement of the train on the system. The tests above given were considered to indicate that the system was fairly satisfactory, as far as amount of fresh air is concerned. Two points further remain to be considered. These are the warming of the car and the exclusion of objectionable material, such as smoke and cinders.

The heating system in the cars, as above stated, embraces about 250 sq. ft. of radiating surface. It is obvious that the temperature obtained in the car from this amount of surface is a function of the steam pressure maintained in the radiators, of the amount of air taken through the heater boxing per hour and of the temperature of the outside air. Clearly it would be expected that if the amount of air supplied is constant at any given condition of the thermometer outside, the temperature inside would vary with the steam pressure; or again, if the steam pressure is constant, the thermometer outside being as above, the temperature in the car would depend on the amount of air taken in. In order to find out exactly what the system would do in the matter of car heating a car fitted as above described, was run from Altoona to Harrisburg in January when the temperature outside during the whole trip was from 10 to 13 degs. Fahr. above zero. Thermometers were employed to measure temperature, and the car was without passengers, in order to afford opportunity for manipulation. The steam pressure maintained, although not measured on this particular car, was from readings on the gauge on the locomotive, believed to be about 20 lbs. During the trip the following points were fairly satisfactorily demonstrated: 1st, There is no difficulty whatever in keeping the car comfortably warmed in such weather with the ventilating system in full normal operation. The thermometer on the bell-cord hanger in the middle of the car, at no time throughout the whole trip showed less than 70 degs. Fahr. and most of the time was from 73 to 75 degs. Fahr., and on one occasion reached 77 degs. 2d. The distribution of heat throughout the car was entirely satisfactory. Thermometers in different parts of the car did not show differences of more than two or three degrees. 3d. Diminishing the amount of air supplied to the car, increased the temperature, which is what would be expected. Upon this latter point some further experimentation is desirable. The amount of work planned for this trip was full enough for the time, and the experiments on increased and diminished supply were not started until toward the end of the trip. The indications, however, were clearly as above stated.

An interesting feature developed during this run was in regard to the behavior of the two sides of the car. It will be remembered that there are hoods and down-takes on diagonally opposite corners of the car, one being, therefore, on the front end and the other on the rear end of the car when it is in motion; also that each down-take connects with its own radiating system, and that these are entirely independent, except that they take steam from the same point of supply. Are now both sides of the car equally efficient in supplying air when the train is in motion? The indications obtained during the trip above mentioned are that this depends largely on the direction of the wind. With the wind dead ahead, both sides seemed to be equally efficient, with the wind ahead and from the right of the line of the train movement, the right-hand side of the car seemed to be most efficient, and with the wind from the left, the left-hand side of the car seemed to do most of the ventilating. The direction of the wind was noted by observing the locomotive smoke and the movement of the air by holding delicate anemometers at the air exits in the car under the seats.

Tests subsequent to those mentioned above, seem to put beyond question the possibility of keeping the car abundantly warm during any weather, even when the ventilating system is in full normal action. Careful observations of temperature were made by a competent person during the trip from Philadelphia to Altoona, with the thermometer outside from 2 to 5 degs. Fahr. below zero most of the distance. It was easy to keep the thermometer on the bell-cord hanger 70 degs. and above. No record was made of steam pressure on the car, but 30 lbs. were used on the locomotive. An interesting feature developed during this trip, viz., the windows were heavily frosted at starting, owing to a little leak in the steam pipes while the car was being warmed up in the station. This frosting entirely disappeared in the course of an hour and a half, owing to the constant passage through the car of dry warm air.

Finally, in regard to possibilities of keeping the car warm, observations were made on a day train during the blizzard of February, 1899. This train was blocked by snow on the east end of Rockville bridge, near Harrisburg for over four hours. The location gave full sweep for the wind blowing down the Susquehanna River, and at times the cars would sway from the force of the blast. One of the five trial cars happened to be in this train, and during the time mentioned frequent observations were made on the temperature. At no time was any discomfort experienced, and at no time did the thermometer on the bell-cord hanger show less than 70 degs. Fahr.

In regard to the amount of steam required to warm the ventilated cars, no very positive data have been obtained as yet. The number of cars fitted with the new system is yet too small to make the question a very serious one. It seems evident that more steam will be required than if the cars were not ventilated, but whether this is going to make a serious drain on the locomotive or not still remains to be proven. A few through trains having from three to five ventilated cars in them have been operated with perfect success for over a year.

A single point bearing on the use of steam may be worth mentioning. At one time during the experimental work, a gauge fitted to show both pressure and vacuum was put on the radiator. As is well known, the system of heating in use is the return system, the water of condensation being taken back to the locomotive by means of a pump, which often produces a vacuum in the return pipe, which vacuum may extend into the radiator itself. On the occasion described the car was in a train moving about 40 miles an hour, the temperature outside about 20 degs. Fahr., and a very large volume of air, probably over 100,000 cu. ft. per hour, was passing through the car. The gauge on the radiator was indicating a vacuum of 5 or 6 lbs., when suddenly the train was stopped by signals. In a very short time, probably less than two minutes, the same gauge showed a pressure of 10 lbs. The explanation seems to be that while the train was moving, the heat was taken away from the radiators so rapidly by the incoming cold air that the steam condensed as fast as it was supplied, and the vacuum of the return pipe prevailed in the radiator; while, when the car stopped, the flow of air and consequently the removal of heat was so diminished that the steam supply was able to produce a pressure in the radiator. The vacuum appeared again, a short time after the train started.

In regard to the exclusion of smoke, cinders, dust, noxious gases, etc., it is to be confessed that if any of these substances are supended in or mixed with the air which comes to the hoods, they cannot fail to be taken in along with the air. Cinders, however, of any appreciable size, are excluded by the gauze over the hoods. Small cinders that pass the gauze apparently pass out the small holes at the foot of the down-takes, or are deposited in the conduit between the sills. The location of the hoods on the top of the lower deck is believed to very greatly diminish the possibility of dust from the track being a serious source of annoyance. The smok from the locomotive with the noxious gases which it car ies is usually considerably higher than the hoods, or is diverted on one side of the train or the other by the wind. This leaves only the conditions concomitant to long smoky tunnels to be especially provided for. The closure of the valves in the down-takes and the rapid change of air in the car by the system, only about four minutes being required to completely replace the air in a car, after it has passed the tunnel, so greatly mitigate this difficulty that no serious trouble has thus far been experienced from the introduction by the ventilating system of objectionable material from without.

It may be fairly stated that practical experience with the system on this road has thus far been very gratifying. Both passengers, officers and trainmen seem to find in the new system such an amelioration of previous conditions that it is not rare for them to pronounce it a marked success. The tendency to open the windows is very greatly diminished, and the possibility of running with closed doors in the heat of summer is clearly noticeable.

One difficulty still remains to be overcome. The partial closing of the ventilators over the lamps results in a tendency to smoke the headlinings. Apparently the apertures left are not quite large enough to completely carry off the lamp gases. In order to overcome this difficulty it has been proposed to combine the Globe ventilator and lamp ventilator into one. Such combined ventilators, increasing the apertures for the escape of the lamp gases and at the same time retaining the essential control of the ventilating system, are now on trial.

THE LOCOMOTIVE TESTING PLANT.

Its Place in Railway Equipment.

By Robert Quayle,

Superintendent Motive Power, Chicago & Northwestern Railway.

While locomotive testing plants have come into somewhat extended use within the last few years, they are still few enough in number to excite interest as stationary appliances for accurately determining data in regard to the performance of locomotives.

Probably the first effort of this kind, outside of Purdue University, was made when the writer was Master Mechanic of the old Milwaukee, Lake Shore & Western Railway, at Kaukauna, when an engine truck was inverted, placed in a pit and fitted with brakes to retard the carrying wheels themselves, in order to absorb the power of the locomotive whose drivers rested upon them. The present testing plant in use at the Chicago & Northwestern shops at Chicago was built in the spring of 1895 and was complete enough to permit of making a large range of practical tests upon it, thus demonstrating the various efficiencies of a locomotive. The wheels of the present plant, upon which the drivers rest, are of large size so that the speed of retardation is slowly reduced, the diameters being practically the same as of the locomotive drivers themselves. The plant has been so often referred to and described that it is probably unnecessary to give any further details in regard to it.

The first tests on this plant were made in July, 1895, and were made principally to demonstrate the best practice in regard to settings of slide valves and the allowance of lap and lead which should be given them under different circumstances. After that a test was made comparing compound and simple engines. One of the very interesting facts brought out in a test that was made later on in the same year was that the springing of the eccentric rods would cause a remarkable decrease in the opening of the valves. This was the case with an engine which had rather long eccentric rods bent over the axles, and it was found that when the throttle was wide open the steam chest pressure caused so much friction that the port opening was reduced by a very large percentage. This led to trials with various sized ports, and it was found that with unusually long ports the friction of the valve was so much increased that there was actually much less real opening than with a shorter port and less resistance.

The test made to determine the best arrangement of front ends, in connection with the Master Mechanics' report of 1896, is too well known to require any further recapitulation, except to say that it would be practically impossible to maintain uniform conditions so necessary for such a test on anytning but a stationary plant.

One quite interesting test was the comparison of two engines of the same type: one engine being pronounced a very good one and the other a very poor one. Deductions made on the testing plant showed that there was practically no difference in the work done by these two engines and that the whole question was merely an idiosyncrasy of some people connected with the handling of the engines.

Owing to the varied nature of the service when an engine is running upon the road, it is practically impossible to make tests which will give us definite information in regard to the relative value of different applications of various contrivances. The writer has frequently known cases where the difference between runs with the same device will be greater than between runs with different devices. As soon as an engine is brought into proper condition, and the reverse lever, throttle, etc., are in the desired position ready to take a test we either get a red flag or a signal is thrown up in front of the engine which compels a stop, and thus the conditions are lost, and this almost always repeats itself time and time again.

With the testing plant, however, a certain set of conditions may be maintained for an hour or more and we are thus en-

abled to accurately determine the proper adjustment of the front end, lead, diaphgram, exhaust nozzle, netting arrangement, valve setting and even the kind of lubricators or other devices and their operation may be much more satisfactorily noted than in a service or road test. Service tests, however, are not to be deprecated and the testing plant can never entirely take their place. In some recent experiments this was particularly well brought out and a combination of the two worked out in a very interesting manner.

A full set of tests was made on the standard freight engine of this road upon the testing plant, in order to obtain information in regard to the coal consumption at various speeds and expansions. These tests are described at length in this issue of the American Engineer by Mr. Henderson. The conditions were continued where possible for an hour so that the consumption of coal could be properly determined for an adequate length of time. From these, diagrams were plotted showing the consumption which might be expected under different conditions of speed and cut off. The engine was then tested with a dynamometer car upon the road and by noting the draw-bar pull which was obtained during the different conditions of speed and cut-offs we were able to deduce very closely the amount of coal needed to give various draw-bar pulls at different speeds. This was applied by working the engine up to the increased consumption of coal due to higher speeds, and this was really the prime motive in making these tests. It was found for instance that while 7 lbs. might be expected in the way of consumption per 100-ton miles at 15 miles an hour on a level, that at 30 miles an hour the consumption would be more than double or would average about 17 lbs. per 100-ton miles. With the same information we were enabled furthermore to give locomotives a proper rating, one that we are sure they can pull without difficulty, and yet which will not allow them to go underloaded. It is, of course, known that to run trains at higher speeds they must be reduced in weight, and these experiments also give us the ratio of decrease in order to maintain higher speeds on level tracks or on varying grades.

These problems are so intimately connected with the economical operation of motive power, that it is needless to give any additional examples of the results obtained from the testing plant in order to illustrate its commercial value and as its cost amounted to about $3,000 it is unnecessary to say that we have felt more than repaid for the expenditure made upon it.

IS IT GOOD POLICY FOR RAILROADS TO BUILD THEIR OWN LOCOMOTIVES?

Obviously, the answer to this question can be found only by a careful analysis of the facts in detail for and against this policy. Dividing the problem into the following parts we have:

First, its relation to the business interests of the railroad as a common carrier. Second, the direct economy in difference of cost. Third, reduced cost of maintenance incident to a possible higher standard of workmanship, securing greater interchangeability of parts. Fourth, greater efficiency as adapted to the demands of the service.

A railroad corporation, as a common carrier, is a public servant whose business is the carriage of passengers and the hauling of freight. The latter item being by far the source of largest income and profit, and directly proportionate to the amount of manufacturing located and carried on along its lines, these manufacturing industries, therefore, constitute a patronage which is to be fostered and encouraged by every legitimate means. This fact has an important bearing on the question. As a further incidental to the faithful performance of this duty as a public servant, and that this service may be available at any time, according to demand, specially skilled employees are maintained in the various departments as a permanent force; a characteristic of every well-organized railroad.

It will be obvious that in the duties and the organization there is not only no provision logically to be made which would include the railroad as a manufacturing competitor, and that it is also a fact that any manufacturing on the part of the railroad itself, competing with a similar industry along its lines, would only antagonize and probably would result in the loss of freight traffic. Furthermore, the amount of money saved by the best possible arrangement of organization on a railroad in the manufacture of that which could much better be purchased is a great deal less than the profits on the freight lost as a result of this policy. We have never known a case in which the railroad with its peculiar kind of skilled labor and organization could compete with the manufacturer on any article which they were attempting to make. The reasons are: First, a first-class mechanic on locomotive work, and perfectly satisfactory on that line of work, is seldom a first-class mechanic or available when compared with the class of skill characteristic of the first-class mechanic in ordinary manufacturing interests. Second, the foremen in charge of departments on a railroad are generally men who have been brought up on the railroad, and with no manufacturing instincts or experience. Third, the absence in the average railroad shops of that atmosphere of competition which is a prominent characteristic of every manufacturing interest. This almost totally eliminates that care in detail, economy in use of materials, and the multitude of small matters which are the keynotes of success or failure.

Considering cost as including only the labor, material and legitimate expenses of the plant which can be charged to output, it is an open question whether, as compared with the average manufacturing concern, a railroad ever does know exactly what a locomotive constructed by them actually costs—for this reason: The system of bookkeeping essential to the affairs in general of a railroad is not such as in all cases absolutely to identify the labor involved with the product. Even if it were true that the system of bookkeeping was the same, the reasons above given should be sufficient to indicate a very large possible difference in cost. In addition to this, there should be charged against a locomotive built by a railroad the proper proportion of cost of maintaining an engineering department incidental to the designing of the locomotive. The very creation and maintenance of this engineering department presents opportunities for the experimentation and working out of personal fancies in the designs created which quite frequently result in failure, and the cost of this also should be charged up against the locomotive. This, however, owing to the peculiar method of bookkeeping, does not show as an item of cost, and is generally paid for from the expense account. Very few railroads, indeed, are so equipped that they can assign to one shop the manufacture of all of their new locomotives, to the exclusion of repair or other work strictly incidental to maintenance. And in such shops, where this cannot be done, and the two kinds of work are carried on at the same time, the fixed force which must be maintained for emergencies and regular operative purposes constitutes practically a fixed charge, which, in the absence of anything else to charge it to, must be borne by such new work as may be turned out.

It is quite possible—in fact, in some cases we know it to be true—that there is a saving in cost of maintenance of locomotives built by a railroad company, owing to the fact that while it is not so written in the bond, it is understood that the work turned out must at any cost be interchangeable and absolutely standard. While this increases cost of manufacture in many cases, it results in less detention in repairs, a greater mileage, and reduced cost per train mile for maintenance. We think, however, that there are very few, if any, locomotive builders who cannot guarantee to produce similar work if it is insisted upon and proper drawings are furnished and thorough inspection is available. This kind of workmanship is directly the result of skilled labor and careful supervision, and it would hardly be fair to assume that the average locomotive concern is not even better equipped in this particular than any railroad. In addition to this, the competitive feature and the necessity for constant improvement in methods which will reduce cost and increase output, a necessary characteristic of their business, is greatly in favor of lower first-cost to the railroad company.

Owing to the difference in traffic demands, gradients, curvature, coal, water, etc., various modifications from one standard design are required to fulfil satisfactorily the various demands of service. And while it is true that a railroad equipped with an efficient department able to work out these problems as adapted to that particular road, it is frequently the case that the tendency of this department will be to originate rather than adopt the best existing practice, thus leading not only to expensive failures in the locomotives built, but also to wasteful delays of traffic. This is especially the case where not only are the designs made but the locomotives actually constructed by the railroad company itself. It would seem more reasonable that the locomotive builders, who are not only designing but building for railroads all over the country, and keeping records of performance of the various types of engines built, should, when supplied with the essential data, be able to furnish a more satisfactory and economical design of locomotive than the average created by the railroad company in its engineering department and at much less cost.

WIDE FIREBOXES FOR SOFT COAL.

By F. A. Delano,

Superintendent Motive Power, Chicago, Burlington & Quincy Railroad.

It has been recognized by locomotive designers for some time that the high speeds required, both in passenger and freight service, as well as the reduction of grades and the consequent handling of trains more nearly up to the maximum cylinder tractive power of locomotives, have made demands on locomotive boilers far in excess of their economic capacity. In order to meet these demands there has been a steady increase in the size of boilers, increasing the diameter in order to adequately increase the heating surface, but the chance to increase the grate area proportionately with the heating surface was limited in the ordinary bituminous coal burning engines to the available width between driving wheels (say 40 ins., putting the firebox over the frames) and a maximum length of say 9 to 10 ft., and making the total maximum grate area say 30 to 33 sq. ft.

In the summer of 1899 the Chicago, Burlington & Quincy Railroad began the construction in their own shops of four freight engines like a mogul in type, but with a trailing wheel behind, where the shell of the boiler was made long enough to place the firebox entirely behind the back drivers. While this construction compelled the use of an excessively long boiler shell, and flues of a hitherto untried length, it did admit of widening the firebox to any convenient width, still maintaining a relatively deep firebox without raising the center of the boiler to an undesirable height.

This design was rapidly followed by modifications adapted to passenger service as well as freight, prominent among which may be mentioned those of the Schenectady Locomotive Works, the Pennsylvania Railroad, the Brooks Locomotive Works, the Lake Shore Railroad and the Baldwin Locomotive Works, the examples of which are on record in this journal. The essential feature of each is the long barrel or shell of the boiler, the firebox widened to any convenient figure—thus far within the limits of 5½ and 7 ft.—making an engine heavy at the back end and spoken of by some critics as a "Kangaroo" type. This back end has been supported on a single pony trailing truck the carrying gear for which has been the subject of a good deal of ingenious design.

The widening of the firebox beyond the limit of the width available between the driving wheels is no new thing in anthracite and "coal dirt" burning engines. It has been the practice for years to use shallow but excessively wide fireboxes, but the experience of some years ago with this firebox in handling Western bituminous coal seemed to show that the grate area was excessive and the firebox too shallow for lump coal, so that a compromise width and a more moderate total grate area, having greater depth, is coming into use, at least experimentally.

Great differences will be found between the extremes in ratios of grate area to heating surface; also between extremes in the ratios of grate area and heating surface to cylinder volume, for example: The ratio of total heating surface to grate area of about 35 to 1 with certain recently constructed Wootten type fireboxes especially designed for bituminous coal is to be found, and side by side a ratio of 110 to 1 is found in an extreme case of narrow firebox for an excessively large boiler. It seems to the writer that there might be a wise "golden mean" between these extremes and a ratio of say between 50 and 60 to 1 is recommended as being a good ratio for engines burning ordinary bituminous coal. The writer refers to ordinary bituminous screened lump and mine run coals where the coal is not very friable. For crushed coal, screened or not, and small anthracite coals, etc., a larger relative grate area would be required.

In determining the ratio of boiler capacity, as well as the heating surface to cylinder volume, one must know the kind of service for which the engine is required. Running engines on a level road to their full cylinder tractive power requires a boiler of a very large capacity, whereas on a road with undulating grades a much smaller ratio of boiler capacity to cylinder volume can be used to advantage.

The ratio of the heating surface in square feet to the weight in pounds of one cylinder full of steam at boiler pressure gives a figure which can be used in a general way to compare different types of locomotives. I find that in comparing engines of a prominent trunk line this ratio varies all the way from 743 to 1,200. It has been found by experience with engines having a ratio below 1,000, that they have not proved very successful engines for a continuous effort; in other words, they are over-cylindered. [Editor's note.—This use of the term "over-cylindered" has no reference to the weight on the drivers.] The ratio of the latest design of "Prairie" type locomotive for this road, illustrated in the May number of the American Engineer and Railroad Journal is 1,403. This is in excess of all our earlier engines, the next in order having a ratio of 1,111 sq. ft. The lowest ratio on this road is for a consolidation locomotive designed in 1879 and very much over-cylindered for continuous grades or level track. Its ratio is 743. A ratio below 1,000 seems to be an indication that the engine is "tender."

In connection with the, so-called, moderately wide and deep firebox, a grate area of from 40 to 50 sq. ft. is readily obtainable, without making the sides of the firebox flaring or inclined outward. This grate area is only half that which has been obtained in Wootten boilers, but the firebox is considerably deeper, and the possible center of the boiler low even for high-wheeled engines.

What may we hope for this type of construction? In the first place, making the firebox shorter and wider makes it more nearly square, and even in spite of the increased area of grate an ordinary fireman can more easily cover it. Secondly, the shortening of the firebox diminishes the number of staybolts in the side, as well as increasing the thickness of the water legs on the side to any convenient figure. This ought to diminish the staybolt failures for the following reasons:

Because there are fewer staybolts.

Because the staybolts are longer.

Because the side water legs, which are supplied with water from the front barrel, from the water above the crown sheet and from the back leg, will be more readily supplied than if the side legs be long. Third, the intensity of the heat in the firebox, which should materially assist toward perfect combustion, should be greater in a nearly cubical firebox than in a long and narrow one.

The American locomotive on British railways has, aside from the prejudices of their drivers and firemen, labored from the very first under a considerable disadvantage. Mr. Charles Rous-Martin, in a recent issue of "Engineering Magazine" says, that the American engines are not the engines that the builders of this country, knowing the precise local requirements, would have designed for the class of work to which they are put; that the requirements of traffic are looked at by the designers in this country from a different point of view than that of the British designer and the result is an engine that does not represent the matured result of American experience as applied to this particular type of locomotive designing. To this may be attributed the increase in the amount of fuel that is said to be necessary for operating the American engines in a similar work with the British engines. There are, however, no records of coal consumption accessible to substantiate this statement. As to the question of repairs it is yet a little too soon to draw any conclusions, but with the exception of the matter of coal consumption it is the opinion of Mr. Rous-Martin, based upon considerable independent information, that the American engines are doing their work well and are satisfactory.

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JUNE, 1901.

AMERICAN ENGINEER TESTS.

Locomotive Draft Appliances.

For more than two years this journal has contemplated conducting a series of tests for the purpose of furnishing information which the motive power departments of American railroads most need in solving their problems. The subject of locomotive draft appliances, or the front end problem, was selected because it is in a very unsatisfactory state. Practice in this regard seems to lead in circles, and in the absence of information applying to present conditions little if any definite progress is being made. Most excellent investigations in this direction were conducted in Hanover, Germany, in 1894, by Von Borries and Troske, and in this country in 1896 by the Master Mechanics' Association. These, however, are not applicable to the changed conditions of to-day, and we hope to supplement this excellent work and render it available to present and future designing.

Among railroad officers the idea has received an instant and encouraging response wherever it has been mentioned, and this tends to confirm the original determination to make the investigation thoroughly worthy of the subject.

As the first preliminary Mr. H. H. Vaughan, Mem. A. S. M. E. and formerly Mechanical Engineer of the Philadelphia & Reading Railway, has prepared an able analysis of the subject. We are fortunate in securing his assistance and in having the cordial interest and hearty support of Professor W. F. M. Goss, of Purdue University. Through him and the other authorities of the University the locomotive testing plant of that institution is placed at our disposal for the tests, which is sufficient promise of efficiency and thoroughness. Professor Goss has rendered a report based upon Mr. Vaughan's analysis, with recommendations as to the scope and character of the tests, and has been engaged by the American Engineer to conduct them, under our direction, the work to begin next September. The expense is to be borne by us and our columns will record his final report.

Appreciating the importance and value of suggestions from railroad officers who are in position to bring years of experience to bear upon this subject, we have invited co-operation from those who have given it special attention. On the evening of May 21, in Chicago, the preliminaries were discussed by representatives of the motive power departments of a number of prominent railroads, who met at our invitation. These included the Pennsylvania, New York Central, Chesapeake & Ohio, Lake Shore & Michigan Southern, Chicago & Northwestern; Chicago, Burlington & Quincy; Denver & Rio Grande, and Atchison, Topeka & Santa Fe. At this meeting the outline of tests was approved. These gentlemen unanimously endorsed the plan and voluntarily offered their services as a committee to do all in their power to assist in making these tests the most complete of the kind ever conducted

It may properly be said that the enterprise is well founded, and we may even be allowed to congratulate our readers upon the prospect of securing through our columns the complete record of the investigation. When the tests are under way we shall begin the publication of the large amount of valuable information which has already accumulated in this connection, after which the records in full will follow.

THE MOTIVE POWER OPPORTUNITY.

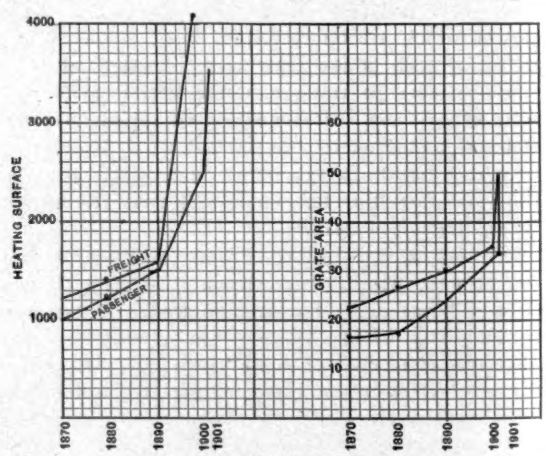
By W. S. Morris,

Superintendent Motive Power C. & O. Ry.,

President Master Mechanics' Association.

The fact that 40 per cent. of the operating expenses of railways in this country come within the responsibilities of the motive power departments is ample justification, especially in the case of one connected with this branch of the service, to consider this work one of the most important factors of railway operation. All departments are but members of the whole body, and I have no desire to exact privileges for the motive power branch because of the proportion of its responsibility, but it is pleasant to be a part of the organization which presents such important possibilities.

In the matter of operation it was not long since a locomotive was merely a locomotive and a car was a car. It did not seem important that they should receive the concentrated thought and knowledge gained by years of preparation and experience, in order that their efficiency as money earners should be of the highest grade. As I understand the present situation, the operation of railroads to-day and of the future depends upon these efficiencies. In this field has appeared the most radical advancement, and in it lies the widest horizon of possible improvement. We have magnificent roadbeds to carry our equipment and we have able executives to operate it, but the locomotive and the car must be carried forward in a development which thus far surpasses all other engineering progress and which bids fair, within the present official generation, to reach a state of advancement at present not dreamed of.



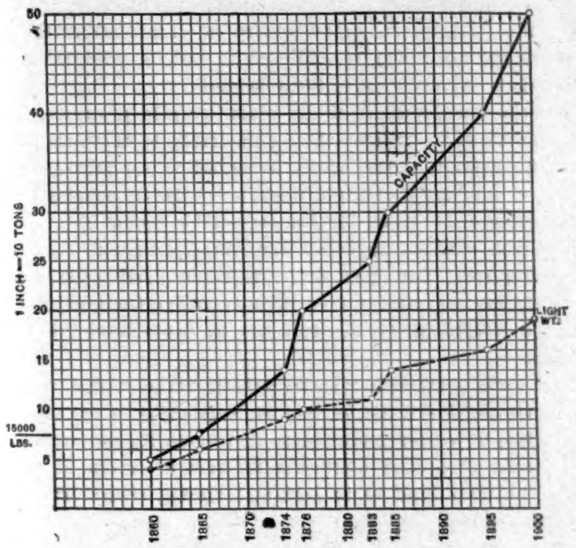
Progress in Locomotives.

Having recently had occasion to look up the progress of the locomotive during the past thirty years and to put it in the form of diagrams, I include two of them here, because they indicate a tendency which will probably surprise even those who have had a hand in the performance itself, unless their attention has been directed to it as mine has been. This space of time has been covered by the experience of motive power officers who are now living and some are yet active, whose names will be found in the proceedings of the first convention of the Master Mechanics' Association. They have seen heating surfaces increase from 800 and 1,000 sq. ft. to 3,500 and 4,000 sq. ft. for passenger and freight service. They have seen boiler pressures rise from 120 to 225 lbs., and grate areas (bituminous) increase from 17 to 50 sq. ft. Tractive power has grown as well, but not in proportion. Mr. Forney expressed the opinion in the

year 1888 that in 1918 locomotives would have boilers 7½ ft. in diameter and that they would weigh 200,000 lbs. These figures have already been approached and those of weight have been passed.

The car, or carrying, problem has kept an even pace with locomotive progress. It is associated directly with the business side of transportation operation, and, "looking backward," the progress in capacities and dead weights from 1860 to the present time in freight cars can be as thoroughly appreciated from the diagrams also included. These are intended to convey ready conception of the accomplishments that have been made, and only a brief period has elapsed to indicate to the observer the financial "Eureka" to be in the heavy tonnage and concentrated load.

No one can tell what the next motive power improvements will be, but this seems to be a favorable time to consider promising suggestions of all kinds. It is my conviction that in the next few years we shall see a surprising change in the



Progress in Cars.

ready acceptance of construction and the employment of principles which are not now considered at all, and that this will result from a broader appreciation of the business side of the motive power problem. If it is necessary to accept greater complications of construction in order to get the desired capacity in power, it will be done, although it would be advantageous to build locomotives and cars with the least number of parts. The men who are to have a hand in this progress are to be congratulated, for it is a work worthy of their best endeavors. The old lines cannot much longer be followed, because of limitations of size and weight. It, therefore, remains to be seen how we shall be able to get the utmost out of the weight and space that are available. This is a new era, because it requires a treatment which has not been found necessary before and here is where the progressive man with the combination of education and responsible experience will find a subject affording all he requires in the form of an opportunity. I do not mean to say that we need radical improvements to-day, but we shall grow rapidly up to the need of them.

In the stream of consolidations comes that of the locomotive builders, which includes all of the large works except the Baldwin. Under the name of the American Locomotive Company, the Brooks, Schenectady, Pittsburgh, Richmond, Cooke, Rhode Island and Manchester Locomotive Works have been consolidated. Mr. S. R. Callaway, formerly President of the New York Central & Hudson River R. R., is President of the new company. The Baldwin, Dickson and Rogers plants are not included in the combination. The combined capacity of all the builders is claimed to be 3,000 locomotives per year, of which 40 per cent. can be supplied by the Baldwin works alone.

LOCOMOTIVE COAL CONSUMPTION.

By M. N. Forney.

One of the subjects to be reported on at the coming convention of the Master Mechanics' Association has been put in the form of the inquiry, "What is the most promising direction in which to effect a reduction in locomotive coal consumption?" This, in different variants, is an old topic for discussion, and much has heretofore been written and said about it, but nevertheless it has not yet been exhausted. It ought to educe an interesting report from the committee which has it under consideration, and this in turn should lead to a profitable discussion, provided that when it becomes interesting, some dull member does not "move that the discussion be now closed."

In a general way it may be said that in a locomotive there are four available sources of economy in fuel consumption:

(1) The coal itself—that is, its quality and combustion.

(2) The boiler and its functions, including the generation and superheating of steam.

(3) The engines and their use of steam.

(4) Heat economizers or feed-water heaters.

With reference to the first it might be said of coal, as the Irishman said of whiskey, that it is all good, but some of it is better than others. As all commercial coal will generate steam, in that sense it may be said that it is good. But some kinds will generate more steam than others. As to which is the most economical depends upon its cost, and with the advent of large fireboxes poorer and cheaper qualities of fuel can be more economically used than was possible with smaller fireboxes and boilers. A great deal of careful and intelligent investigation is required to determine which of a number of different kinds and prices of coal in the long run are the cheapest to use on a railroad. Now, the surprising thing is that so few railroad companies have given any adequate attention to this subject. If, through an accident, an employee or passenger should have his toes cut off and should make a claim for damages, the most skilful legal counsel and expert testimony would be devoted to the defense of the company, and to resisting the payment of the value of the lost toes; but the cases in which railroad managers have been willing to pay anything at all to an expert to tell them how they could save a hundred or a thousand times the amount of his fees, by indicating which was the most economical coal to use, are very few. One reason for this, in some cases, is that the award of contracts for supplying coal is decided with loaded dice, and contracts are given to parties who have "influence" at headquarters. However that may be, it is certain that it would be immensely profitable to almost any railroad company to give thorough and intelligent investigation to the quality of fuel used on its line.

For an adequate discussion of the combustion of coal, a large treatise would be needed instead of a short article like this. All that will be said here is that the best appliance for the combustion of coal and the generation of steam is adequate boiler capacity; that is, sufficient heating and grate surface. The need of the latter has finally come to be appreciated. Some new problems, however, attend the use of large grates, for the reason that if their area is adequate for the maximum service demanded of the boiler, they will be much too large for moderate and minimum demands. The inference from this is that what may be called the active area of a grate should be variable. That is, we should be able to close more or less of the openings for the admission of air through the grate at will, to meet the requirements under which the engine is working. Then there should be adequate room in the firebox above the grates for the commingling of the gases to produce perfect combustion.

Our existing knowledge of the elements essential for efficiency of a locomotive boiler may be summed up by saying that a large grate, plenty of room in the firebox, and ample heating surface are most needed. Everything else seems to be merely

accessory and not essential for the economical generation of steam.

With reference to superheating, however, the case is quite different. Here we are still on the dangerous sea of experiment, but with the knowledge that there is a land which is very promising and productive beyond. It has been proved conclusively that very great theoretical economies are a possible result of superheating. It is therefore a subject well worthy of consideration and investigation.

With reference to the engines and their use of steam at the present juncture, interest will be concentrated on the question of compounding, and probably there will still be much disagreement about the saving due to that system. That a theoretical economy is possible is, of course, conceded, but what a complete debit and credit account containing all the plus and minus elements of cost and saving in the problem would show, at present, "no fellow can find out." A few years ago it was proposed in the columns of the American Engineer that the various committees who report annually to the Master Mechanics' Association should summons any of its members to appear before them to be questioned and to give testimony on the subjects under consideration. A cross-examination of some of the members of the association, with reference to the performance of compound locomotives, would be very interesting, and, it is thought, instructive. It is to be feared, however, that this proposal will not be carried out.

The limits of this article make is possible to devote but little space to the subject of feed-water heaters. That vast quantities of heat escape from the chimneys of locomotives and are wasted needs no evidence to prove. The problem is to catch it and make it useful. It has been clearly shown that with a boiler pressure of 200 lbs. and an initial temperature of feed water of 60 degrees that there will be an economy of over 1 per cent. for each 12 degrees that its temperature is raised before it enters the boiler. Smokebox temperatures of 1,200 degrees are not unusual. If the feed-water could be heated to half of that, or 600 degrees, there would be an economy of 45 per cent. To quote a Hibernian remark—"To say it is easy, but to do it!" The latter requires a large area of heating surface, as is shown in the "economizers" used on some stationary boilers. The problem on locomotives, however, is not regarded as insoluble, and is well worthy of thorough consideration by the committee and the Association.

How much to allow competitors to know of our methods and how much to try to conceal from them is a troublesome question to many people. We are in hearty sympathy with those who believe the absolutely "open-door" policy in this respect. A writer in the "American Machinist," Tecumseh Swift, recently expressed what we believe in the following words: "If you can keep your competitor always copying your work, and always looking into your ways to imitate them, you are sure to keep him a certain distance behind you—as far behind, in fact, as it is desirable to have him. Nobody living and no nation on earth can ever get ahead of anybody by following in his footsteps."

A large Allen absorption dynamometer capable of absorbing a wide range of power has, according to the "Journal of the Worcester Polytechnic Institute," been recently installed at the Willimantic, Conn., mills of the American Thread Co. It is made up of three discs each 42 ins. in diameter and ⅝ in. in thickness, running in oil between 1/16 in. copper plates, 46½ ins. in diameter. The casing takes the form of a segment of a sphere on both sides of the set of discs and copper plates, and is built sufficiently heavy to stand a pressure of 120 lbs. per sq. in., although the maximum pressure used in the first tests never exceeded 25 lbs. One, two or three discs can be used, the shaft turning in the hubs of those remaining stationary. The water pressure stands upon all of the discs, but circulates only around those in use. In this way the capacity of the machine may be varied from 10-15 h.p. up to 600-700 h.p. per 100 revolutions per minute or from 2,400 to 2,800 h.p.

TOPEKA SHOP EXTENSIONS.

Atchison, Topeka & Santa Fe Railway.

By R. P. C. Sanderson, Assistant Superintendent of Machinery.

The Topeka shops of the Atchison, Topeka & Santa Fe Railway, like the historic "Topsy," have "growed" from beginnings that were never intended for locomotive repair shops. The original main shop buildings were erected for a bridge shop; these have been added to under the pressure of continued growth, until they have reached the limits of the possible capacity of the available ground. With the growth of business and consequent increase in number of locomotives and enormous increase in the size and weight of the locomotives, it became only too evident that the shops were inadequate to keep up the work that should be done there so that further centralization of the locomotive repairs and standardizing of the repair work with consequent manufacture of interchangeable parts to gauges for use along the line could not be undertaken until further shop capacity could be provided.

While the development of the plans were in progress, earnest effort was made by improved shop methods to increase the output of the present plant, which resulted in an increase in the number of engines receiving classified general repairs from 12 per month for 1899 to 20 for January, 1901, 29 for February and 32 for March without any very material increase in the number of men employed and only a few additional machines, but this could only be done under great disadvantage for lack of cranes and proper facilities which could not be introduced into the old buildings.

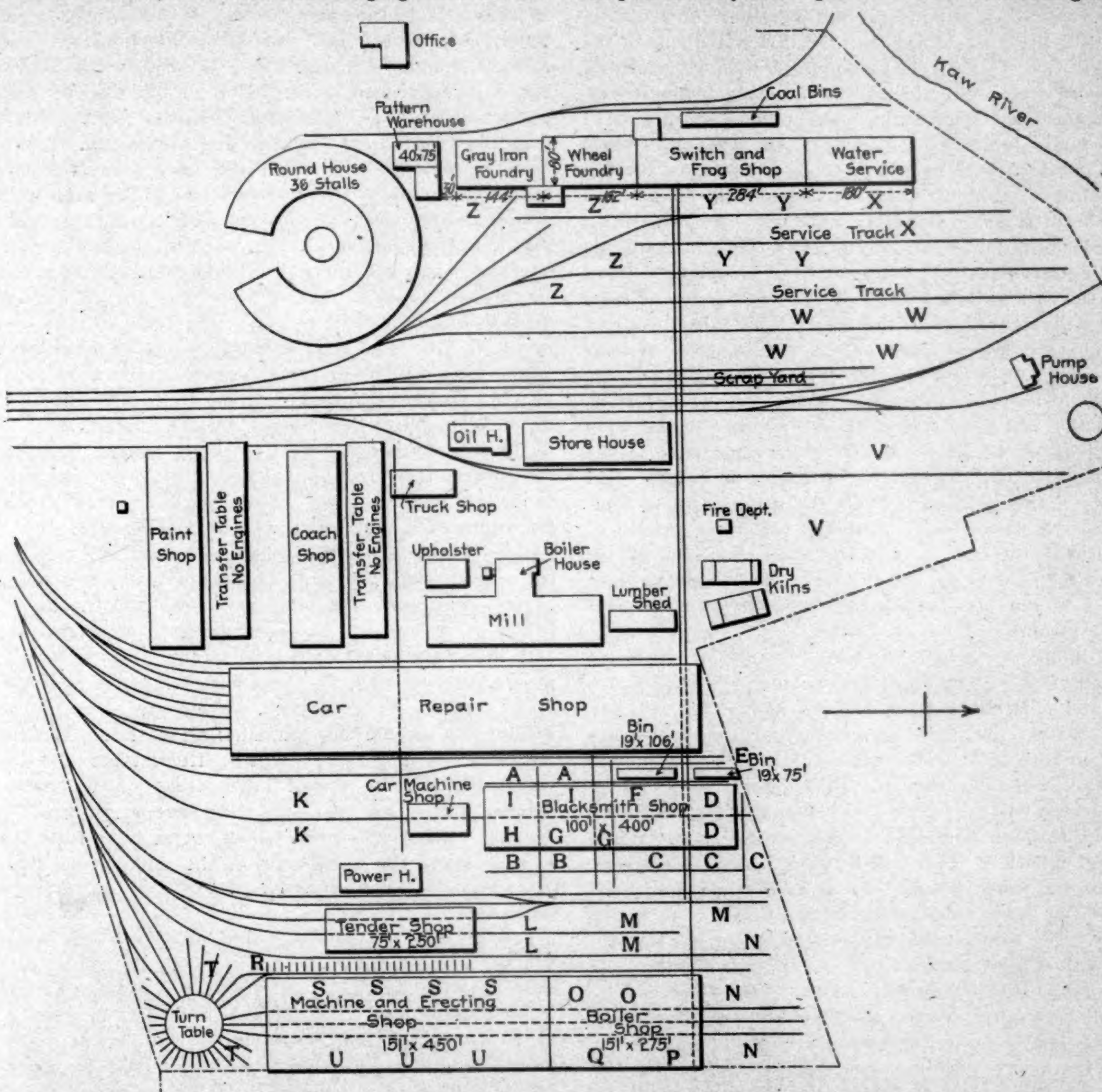
There were operating reasons which made it desirable that the new shops should be located at Topeka, or a far more convenient layout could have been arranged for at some other point where land was available in greater areas at less expense. The only land to be had at Topeka, within reasonable cost limits, was to the eastward of the present freight car repair sheds and bounded by a street, by improved property and by the general freight yards, so that the problem resolved itself into one of making the best layout for the land available and not of making the most perfect arrangement regardless of land limitations. In the plan of the layout shown herewith all the buildings to the west of the smith shop are the present old shops, the car department, both freight and passenger, the storehouse and planing mill remain unchanged. The buildings marked foundries, frog and switch shop, etc., are the present old machine erecting, boiler and smith shops. There are, however, on the yards east of these buildings a number of wings and separate buildings which are to be torn down so as to make a serviceable yard for handling pig iron, scrap, coke, flasks, sand, etc., for the foundries and for rails, frogs, switches, etc., for the proposed frog and switch as well as water-service shops.

Referring to the new buildings. The blacksmith shop, now being erected, is a steel frame structure, 199 by 400 ft., very strongly built and braced. It is located next to the freight car shops and as close as possible to the storehouse, so that the car forgings, bolts, etc., can be delivered with the least possible handling direct through the small machine shop, where the threads are cut and axles turned; to the freight-car shop, or on to the storehouse for stock and shipment along the line. At A a storage for dimension bar iron is provided, at B the long bar iron is to be racked, at C the wrought iron scrap is to be stacked, cut by scrap shears driven by a motor out in the yard and prepared for faggoting. The end of the shop, D, is to be the hammer shop and will be well provided with large hammers, including a special new 5,000-lb. hammer for forging axles from scrap. All the furnaces for slabbing and forging under the heavy hammers are grouped in this end of the shop. It is the present purpose to use crude oil for fuel in these large furnaces instead of coal, the oil being atomized by compressed

air. This decision was reached because of the success in the use of fuel oil for furnace work achieved in California and on account of the recent development of the new oil fields in Southern Texas, near Beaumont. It will be noticed that provision has been made at E for bins for smith shop supplies, firebrick, etc., and that standard gauge tracks are arranged so that iron, bricks, scrap, etc., can be switched in car loads direct to the point of storage; this will reduce the handling to a minimun. The fires for heavy work are located at D near the hammers, a convenient arrangement of cranes and tramways being provided for the hammers, furnaces and large forgings.

At G all the bulldozers, bolt headers and forging machines are mounted. At this place also pneumatic loading hoists are to be located for the shipment of axles and wheels to points along the line. Convenient access to the wheel lathes and wheel presses in this shop is provided by means of service tracks and pneumatic jack turntables, which lead to the freight car and coach shops.

Power House.—It is the present intention, although all the plans have not been completely worked out and approved, to deliver the coal by drop bottom cars to the south of the power house; it is then to be elevated by power into overhead bins carrying a couple of days' supply. From these bins the coal will pass directly into a pair of Loomis-Pettibone gas producers



Extensive Shop Improvements, Atchison, Topeka & Santa Fe Railway.

ranked with their furnaces, service tracks being arranged for the handling of the iron from the shears to the machines and from the machines to the machine shop. At H all the spring repair work is to be done, provision being made for suitable furnaces, hammers, banding press and other spring machinery. At I, along the west side of the shop, are the forges and fires with graded sizes of steam hammers conveniently located so as to do as much of the heavy work as possible by dies and power.

The Car Machine Shop at the end of the blacksmith shop will be well equipped with single and multiple drills, punches, bolt cutters, nut tappers, axle lathes, boring mills, wheel presses and wheel lathes for steel tired wheels. Through this shop all the car forgings requiring machine finishing will pass on their way to the car shop or storehouse. The yard space, K, is intended for a wheel yard for storage and handling of new and second-hand axles and wheels, both mounted and unmounted, where the coal will be converted into producer and water gas, stored in separate gas holders after scrubbing and cleaning. A mixture of these gases is to be used for furnishing power in gas engines, which will be direct coupled to electric generators in the power house. This electric current is then to be used for operating the roundhouse turntable, foundry blowers and cranes, frog and switch and water service machinery, transfer tables at the car shops, machines in the smith and car machine shops, as well as all machines and cranes in the tender, machine, boiler and erecting shops, also for electric lighting of the plant and yards.

It is reasonably certain that a brake horse-power can be obtained in this way for about 1½ lbs. of slack coal, while by steam power the best that can be done with the same coal under good boilers is from 7½ to 8 lbs. of coal per brake horse-power. The surplus gas produced over what is needed for

power is to be used in the smith and boiler shops; the producer gas being used in the bulldozer and bending machine and spring furnaces as well as for the boiler plate annealing and flanging furnaces, the surplus water gas being used in the smith's fires by specially designed forges and for small furnaces where welding heat is required. In this way it is expected to very largely increase the output of the shop per man because the heats will be far more rapid and there will be little time lost waiting for heats or building and preparing fires. The resulting forgings will also be much cleaner and better and the objectionable smoke and coal gas will be avoided.

The Tender Shop is a single-story building 75 by 250 ft. This is also to be a steel-framed building, but of lighter construction, as there will be little machinery in it. The western side of the shop over the two tracks is to be equipped with an overhead traveling crane driven electrically, for handling tender tanks, frames, ash pans and steel engine cabs. The eastern side of this shop is for building and repairing tanks, cabs, and frames and will be provided with necessary tools to be driven electrically, including a rapid working spacing punch. There will also be overhead trams for handling material. The yard space, L, is for tender tank plates, angles, tender frame and materials which will be convenient to the shop and can be unloaded there direct from the cars switched to place. The ash pans and steel cabs can be delivered direct to the erecting shop by means of narrow gauge service tracks, not shown on the plans, or handled by flat cars and switch engines over the turntable to the erecting shop. The yard space, marked M, is intended for the storage of boiler and firebox steel as well as other boiler shop material which can be unloaded direct from the cars to the racks. The plates will be carried by trams or cranes right in to the side of the main shop where the boiler work is done. The yard space, N, is for boiler scrap and materials which will come out through the end doors of the main shop and will be stacked there for cutting up, the shipment being done by light cranes direct to the cars, which can be switched there conveniently for loading up.

The Main Shop.—This building covers ground 151 ft. wide by 725 ft. long, and will be used for machine, erecting, boiler, tin, copper and pipe shops all under one roof. This building consists of a main center building with a high roof with lean-to buildings on both sides. The center building is high enough to permit the use of two heavy traveling cranes, to be driven electrically; these will serve the erecting and boiler shops and can run right through from end to end of the shop. When lifting an engine both of them will be used, but when not thus occupied they will work independently. Each crane is to have a 5-ton hoist for light, quick work in addition to the heavy hoisting gear. The western side of the shop, under the lean-to, is provided with overhead tracks running the full length. The east lean-to is for the flue work and this will be served by two 5-ton quick-running overhead electric cranes. These will serve all the heavy boiler shop tools and flanging work, and also all the heavy machine tools. In the boiler shop the space, O, is for the laying-off tables, shears, punches, drills, planers, flanging press and furnace and floor for setting up work; this latter will also be done partly in the center aisle of the boiler shop under the main cranes. The space, P, in the east lean-to is for the flue work where all this work will be done. At Q will be the riveting tower, 65 ft. high, with an overhead electric crane and a new hydraulic riveting plant, suitable for heavy work. The rest of the boiler shop space will be needed for boilers under repairs and construction. Shells and fireboxes can be thus handled entirely by cranes and swung from crane to crane, which should cheapen the cost of labor considerably.

The intention is that engines going into the shop for repairs will be taken in by two of the tracks leading to the 100-ft. turntable at the south end of the main shop, leaving the third track for outgoing engines so that they can pass without interference.

The turntable is large enough to take a short switch engine and a large road engine without its tender. The engines going in for repairs are to enter on the two outside tracks and will be stripped under the cranes at the south end of the shop. When stripped they will be lifted off their wheels and boxes by the overhead cranes and carried down the shop to the place on the side tracks on which they will be repaired. The driving wheels left behind on the stripping stalls will be rolled back to the turntable and placed on a succession of short spur tracks which will be just long enough to each hold a set of drivers and a truck complete. There will be enough of these spurs located along the west wall of the shop to accommodate all the engines that will be in the shop at one time, each set to itself—these spurs will be in the space marked R. The wheel lathes, boring mills, axle lathes and quartering machine will be located inside the shop at S, and will be served by the light overhead crane already mentioned. The wheels can be handled by service tracks and traveling pneumatic jack trolleys direct from the spurs to the machines and back again. When engines come in for fireboxes, which will have to wait for the boiler shop, the boilers will be carried to the boiler shop by the large cranes and the skeleton run back over the turntable and stored on the radial spur tracks, T T, until the boilers are far enough advanced to be put into the erecting shop. These skeletons are to be put off and on the table and tracks by an electric capstan located on the center of the table so that no labor to speak of will be needed for this. As before mentioned, all the heavy tools will be in the west side of the shop at S, served by the overhead cranes and driven by individual motors so as to be completely independent. All the lighter repair tools will be in the east lean-to at U, run by belting from short-line shafts driven by motors, the tools being grouped together as the work requires them to be associated, each group having its own motor, so that it will be independent. Above these tools over the space U will be a second story in which all the special and other tools needed for manufacturing standard parts, brass work and oil cups, as well as the tin work, air brake work, etc., will be done; it being the intention to separate this work as far as possible from repair work proper and a separate tool room, with gauges, templates and jigs is provided for this work upstairs. There are to be two elevators serving the second floor for handling material. Engines which are ready for their wheels will be lifted across upon the center track, where their wheels have already been placed by the cranes. There they will have their rods put up and be run out for trial. As there is room for an engine hung from the cranes to pass along the shop between the middle and side tracks, there need be no interference between the incoming and outgoing engines.

There is another feature of this building which is of passing interest, namely, the roof construction. The center roof of the main building will have an A frame of usual pitch, but it is to be covered with tiles. The lean-to roof is what is known as a saw-tooth roof, with ridges running at right angles to the length of the shop; the slopes will be covered with tiles but the vertical faces of the teeth are glazed and all faced to the north. It is believed that this will give a very light shop without the usual trouble from leaky skylights—and as far as the writer knows, this is the first railroad repair shop that has been roofed in this way. The turntable was a necessity at the end of the main shop on account of the boundary lines of the land, but it will be seen that it also has its advantages in handling the engines in and out of the shop. The whole plant will be served with compressed air for hoists and pneumatic tools, and will be heated by steam and perhaps by waste gas from the gas engine exhaust. Ample water service mains, sewerage, as well as lavatories, closets, offices, etc., will be provided.

Yards.—The yard space, W, is the general scrap and wreckage yard where scrap coming in off the road will be culled, sorted, straightened and prepared for loading and delivery to the smith shop or foundry or for sale. The yard, X, will be used for water service supplies and materials, the work done in

this department is intended to consist of repairs to and manufacture of pumps, tanks, hand cars, signals and crossing gates. The yard, Y, is for frog and switch shop materials and this shop is intended to be equipped with a new oufit of special tools for repairing and perhaps making frogs, switches, switch stands, etc. The yard space, Z, is for foundry supplies and cast scrap, the intention being to fit up the gray iron foundry first as soon as the move in to the new machine and erecting shops is made, but the wheel shop question is to remain for future consideration. The yard space, V, is for lumber, of which in the west large stocks have to be carried.

The above represents the outcome in a general way of much study and thought given this problem by the writer, assisted in detail work by Mr. Ben Johnson, Engineer of Tests. The work is progressing steadily, the smith shop building being now under erection, and it is hoped in the course of 12 or 15 months to have the whole plant, at least as far as the new portion is concerned, in full operation when the output of engines should, under normal conditions, run up to 50 or 55 per month.

LINK MOTION AND PISTON VALVES.

By C. A. Seley, Mechanical Engineer, Norfolk & Western Railway.

The general type of locomotive valve motion used in this country has long been the familiar Stephenson link, acting through a rocker to impart motion to the valve, producing what is commonly known as an indirect motion, so-called on account of the reversal of the direction of action by the rocker. This feature is necessitated by the movement of the valve in relation to that of the piston; it is familiar to most readers of this journal and is shown in the diagram, Fig. 1. The main driving axle bearing the eccentrics is shown at A and the crank at B, its direction of motion being indicated. The valve is of the outside admission type and the indicated movement of the stem is to open port S, admitting steam to the front end of the cylinder for the backward stroke of the piston.

Attention is called to the relative positions of the eccentric centers shown, both being between the center of the axle and the link and the eccentric rods "open"—that is to say, not crossed. When the crank has arrived at the opposite center to that shown, the arrangement of the parts will be reversed, the rods will be crossed, both eccentric centers will be back of a vertical line through the axle center, the direction of motion of the valve will be opposite to that shown and steam will be about to be admitted to port S¹ for the forward stroke of the piston.

The proof of a correct valve motion is its ability to cut-off equally at half-stroke, for at this point the disturbance due to the angularity of the main rod is a maximum. This is clearly shown by the diagram, Fig. 2. The positions 2 and 4 are those of the crank when the piston is at half stroke in the back and forward movements. In one revolution, starting from position 1, it will be noted that the interval between 1 and 2, measured on the crank circle, is short as compared with that between 2 and 3, while the converse is true of the remaining intervals, from 3 to 4 being long and 4 to 1 short.

Now, it so happens, fortunately, that the irregularities of the angularity of the main rod, of the eccentric rods, the location of the eccentric rod pins back of the link center line, and the varying influence of the two eccentrics working on the link, all work together and correct each other's errors in a measure, and give a motion so nearly correct that usually a small offsetting of the link saddle pin will complete the good work and give a motion that will cut off equally at all points. This result is readily obtained in practice, with engines of normal proportions and arrangement, and we frequently see reports of valve setting showing great accuracy.

The last few years have brought into extensive use the piston valve, which required in many cases special treatment of the valve motion. This form of valve permits either inside or outside admission of steam to the cylinders, and the advantages of the former style have led to its quite general adoption. It permits of using more direct steam passages and offers a better opportunity for the heat insulation of the passages. The valve can readily be lengthened so as to make the steam ports short and direct and reduce clearance. By placing the exhaust at the ends, on the outside, the packing of the valve stem is much simplified and the low expense of maintenance of valve stem packing against exhaust pressure is a very appealing argument in favor of inside admission valves.

Examination of many of the designs of piston valve engines brought out in the past three years show that the favorite location of the valve is in the cylinder saddle in the direct path of the steam to the cylinder. This location is relatively low, so

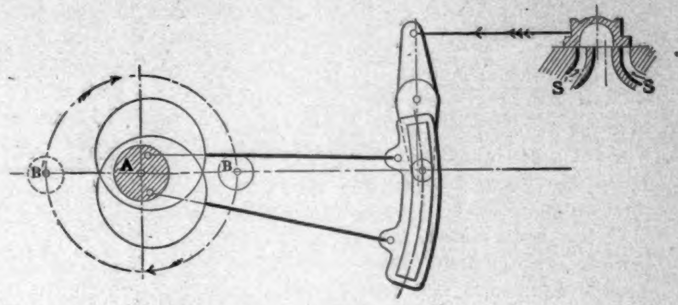


Fig. 1.

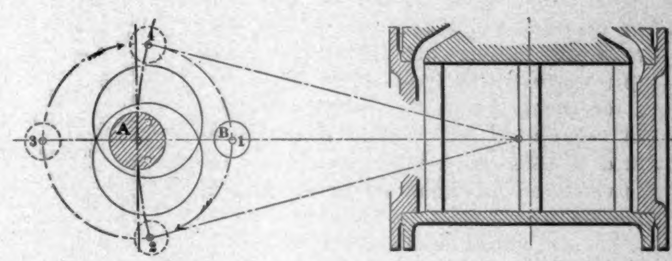


Fig. 2.

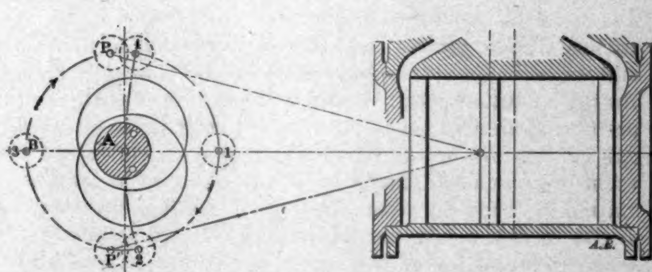


Fig. 3.

that a connection to the link can often be made without the use of a rocker, at least of the reversing type, and the resulting motion is direct. The inside admission valve, having its steam edges inside and exhaust edges outside, is opposite to the arrangement of the "D" slide valve commonly used and as shown in Fig. 1, and requires the valve to be moved in the opposite direction to perform its functions. The reversal of the motion can best be accomplished by the omission of the rocker if other considerations permit.

There may be some good reasons, however, for locating the piston valves over the cylinders of some types of locomotives. It may be that considerations due to brakes, either of reservoirs or of brake cylinders located forward, under the barrel of the boiler, render it desirable to get the valve connections outside of the frames and place the valves over the cylinders. This location also favors a stronger frame construction, which is desirable in heavy engines.

The vertical height of the valve so located is such that it is difficult to make connections for the direct motion desirable

for the inside admission valve. If a rocker and a long valve rod, located outside of the frames, are used, three considerations present themselves. One is to use an outside admission valve. The advantages of the other style have been pointed out. Another is to devise a parallel motion connection between the link and the rocker so as to make it non-reversing. The third is to reverse the motion imparted to the link so that the rocker in transmitting it will give the valve rod the proper direction of motion. This expedient requires that the eccentrics be placed, as it is called, "on the back of the axle," or in a position reversed from that ordinarily occupied by them. This new arrangement can best be appreciated by taking the arrangement shown in diagram, Fig. 1, and putting the crank pin B to position B[1], making no change in the eccentrics. It will be seen that the eccentric centers are still between the axle center and the link, and the rods are open. Therefore, the change of arrangement does not change it to a cross rod system, as might be thought without a full analysis. We do, however, get into a difficulty which will require special explanation.

As has been stated, the ordinary valve motion arrangement, used indirect with outside admission and direct with inside admission, is capable of producing perfect equalization of cutoff, and we have seen by diagram, Fig. 2, that this is done with a certain unequal arrangement of crank intervals with half cut-off.

Reversing the position of the eccentrics in relation to the crank puts the latter into a different relation with these intervals and produces an irregularity of motion which calls for addtional measures for equalization of cut-off. The situation is explained by reference to diagram, Fig. 3. It will be noted from Fig. 2 that the crank in passing from position 1 to 2 travels a short interval and carries the piston to half stroke, and we will suppose the link motion to be ordinarily arranged for cut-off at that point. In Fig. 3 the eccentrics are in the same position as in Fig. 2, but the crank is starting from the opposite center. As ordinarily arranged, the cut-off would occur when the crank had travelled a short interval, or at point P, diagonally opposite from position 2, coming short of completing a half-stroke of the piston. The completion of the semi-revolution leaves the crank at position 1, while the eccentrics are now opposite to the position shown. The motion will now make a half-cut with a long interval movement of the crank, but it requires only a short interval to carry the piston to half stroke. Therefore, the crank overruns, going to position diagonally opposite position 4, or P_1. This brings the piston to the same place as before at the time of cut-off, but it is less than half stroke on the forward and more than half on the return stroke. It is therefore necessary to extend the means of equalization to cover the interval between the positions P and 4 and between P^1 and 2.

The expedients resorted to by the builders of locomotives to correct this irregularity are various, but it is believed that it is not possible to obtain as good a motion in all respects as can be had with the eccentrics normally arranged. The cut-off can be equalized by considerable offset of the link saddle pin, but generally to an amount that would not be permissible with a slide valve. The lesser weight and friction of the piston valve will permit greater off-set, but it will nevertheless result in heavy jarring of the reverse lever and also a distortion of the compression line of the indicator card, indicating that the other functions of the valve have suffered and that the results as a whole are not as good as in the normal arrangement.

It is possible that a modified form of link will give better performance than the Stephenson type, and it is noted that some builders are doing this, but the writer has not investigated any of these forms.

In some recent designs of locomotives, non-reversing rockers are used; that is, rockers with both arms up or down. It will be well in using this feature to provide a very ample bearing for the rocker shaft, particularly as to length. With the ordinary reversing rocker, the pull or push at the bottom arm is met by a resistance at the top arm, in the same direction, and the body of the rocker shaft bears its whole length against one side or the other of the box. With both arms up or down, however, the push or pull on the first arm is opposite in direction to the thrust on the driven arm and the tendency is for the shaft to bear crosswise of the box and wear at opposite corners. If both arms were in the same vertical plane there would of course be no such tendency, but with the arms at opposite ends of a shaft, a sufficient length of bearing should be provided to insure long wear, the longer, within reasonable bounds, the better.

PISTON VALVE LOCOMOTIVES.

Road.	Cyl.	Piston valve. (Admission.)		Location.	Motion.	Frames.	References.	
G. N. Ry.	21 x 34	Outside.	14-in.	Over cyl.	Indirect.	Double bar.	*Am. Eng.,	Jan., 1898.
N. & W.	20 x 24	Inside.	10 "	Saddle.	"	Single bar.	"	Feb., 1898.
W. C. Ry.	19 x 26	"	12 "	"	"	"	"	June, 1898.
W. C. Ry.	20 x 26	"	12 "	"	"	"	"	June, 1898.
G. N. Ry.	20 x 30	"	12 "	"	"	"	"	Oct., 1898.
O. R. & N.	19 x 30	"	10 "	"	"	"	"	Jan., 1899.
B. R. & P.	18 x 26	"	10 "	"	"	"	"	Apr., 1899.
D. R. G.	21 x 26	"	10 "	"	"	"	"	Sept., 1899.
I. C. Ry.	23 x 30	"	12 "	"	"	"	"	Oct., 1899.
D. L. & W.	21 x 32	"	12 "	"	"	"	"	Nov., 1899.
N. & W.	21 x 24	"	10 "	"	Direct.	Double bar.	"	Dec., 1899.
N. P. Ry. (High-pressure cyl. of compound.)	22 x 30	Outside.		Over cyl.	Indirect.	"	"	Dec., 1899.
C. & A.	19 x 26	Inside.	10-in.	Saddle.	Indirect.	Single bar.	"	Feb., 1900.
C. B. & Q.	19 x 24	"	10 "	Over cyl.	"	Double bar.	"	Apr., 1900.
C. B. & Q.	20 x 24	"	10 "	"	"	"	"	Apr., 1900.
N. & W.	21 x 30	"	10 "	"	"	"	†Loco. Eng.,	May, 1900.
C. & N. W.	20 x 26	"	10 "	Saddle.	Direct.	Single bar.	Am. Eng.,	Aug., 1900.
D. L. & W.	20 x 28	"	10 "	"	Indirect.	"	"	Sept., 1900.
C. R. N. J.	20 x 28	"		"	"	"	"	Oct., 1900.
L. S. & M. S.	20 x 28	"		"	"	"	Loco. Eng.,	Nov., 1900.
B. R. & P.	20 x 26	"		"	"	"	Am. Eng.,	Nov., 1900.
B. C. R. & N.	19 x 26	"		"	"	"	‡R. Gaz.,	Nov. 30, 1900.
N. Y. C.	21 x 26	"	12 "	"	Direct.	"	Am. Eng.,	Feb., 1901.
L. S. & M. S.	20 x 28	"	11 "	"	"	"	"	Mar., 1901.
A. T. & S. F.	20 x 28	"	10 "	"	"	Double bar.	R. Gaz.,	Jan. 25, 1901.
B. R. & P.	20 x 26	"		"	"	"	Am. Eng.,	Dec., 1900.
B. C. R. & N.	19 x 26	"		"	"	"	R. Gaz.,	Nov. 10, 1960.
N. Y. C.	21 x 26	"	12 "	"	"	"	Am. Eng.,	Feb., 1901.
L. S. & M. S.	20 x 28	"	11 "	"	"	"	"	Mar., 1901.
A. T. & S. F.	20 x 28	"	10 "	"	"	"	R. Gaz.,	Jan. 25, 1901.
N. Y. C. (High-pressure cyl. of compound.)	23 x 32	Outside.		Over cyl.	Indirect.	"	"	Mar. 1, 1901.
So. Pac.	20 x 28	Outside.		"	"	"	"	Mar. 22, 1901.
C. R. I. & P.	20½ x 26	Inside.	11-in.	Saddle.	Direct.	Single bar.	Am. Eng.,	Apr., 1901.
B. & M.	20 x 30	Outside.		Over cyl.	Indirect.	Double bar.	R. Gaz.,	Apr. 5, 1901.
So. Pac. (High-pressure cyl. of compound.)	23 x 34	"		"	"	"	"	Apr. 5, 1901.
C. B. & Q.	20 x 24	Inside.		"	"	"	Am. Eng.,	May, 1901.
P. M.	20 x 26	"	10½-in.	Saddle.	"	Single bar.	R. Gaz.,	May 3, 1901.
W. C.	20 x 26	"	12 "	"	"	"	"	May 10, 1901.

* American Engineer and Railroad Journal. † Locomotive Engineering. ‡ Railroad Gazette.

A table is given herewith, taken from the Railway Press, and includes probably most of the piston valve engines built since the beginning of 1898. The list covers a variety of sizes and styles, so that much material for study is available for the student in this line. It indicates that the piston valve engine is being very largely adopted by a number of railroads, but it will be noted that the list does not cover the piston valve so largely and successfully used in the Vauclain compound engines.

In conducting experiments to ascertain the value of improvements of any kind it is important that they should be so conducted as to permit of attributing the savings to the proper influences. Usually this cannot be done if several changes are made at one time. They should be made separately and the effect noted independently. It often requires careful study to correctly judge of these matters and nowhere does this apply more forcibly than in railroad practice. It is a good rule to isolate the unknown quantities by trying one change at a time, particularly in case there are several variables under consideration.

GRATES FOR BURNING FINE ANTHRACITE COAL.

By W. McIntosh, Superintendent of Motive Power, Central Railroad of New Jersey.

The advent of the large locomotive with a firebox having a grate area of from 60 to 90 sq. ft. has emphasized the desirability, if not the absolute necessity, of some mechanical means of stoking them and opens up a golden opportunity for some enterprising inventor to meet the occasion and not only reap a liberal financial reward but confer, in addition, a boon to the fireman in relieving him from severe labor and another on the railroads by furnishing the means of obtaining uniform steam pressure for every demand, extending thereby the efficiency of the locomotive and incidentally, expediting the movement of trains and traffic generally.

Were bituminous coal alone to be considered the problem would be greatly simplified. Complications arise when the "buck," "rice" and "culm" varieties of anthracite are encountered, and not to my knowledge has there been a really successful rocker grate brought out to handle this class of fuel independently of the water grate. True, there are engines running right along burning anthracite coal on forms of shaking grates without the water bars but at a considerable expense in renewals as they burn out rapidly with this fuel. These may be described as follows:

First. Sections of ribbed grates 12 ins. wide and 24 to 30 ins. long with trunnions on the ends resting on suitable frames, and, in a firebox of 80 sq. ft., divided into six separate divisions for convenience of operating.

Second. The same design of grate in longer sections and in two or four divisions, their durability diminishing in proportion to increase in length.

Third. Ribbed grates from 6 to 8 ins. wide and 4 to 5 ft. long mounted on bars running lengthwise of the firebox, the ends extending through the boiler head and square to receive the shaking lever. These are the most satisfactory of the types described, but all are short-lived and none work the fire as thoroughly as desired, having more of the waving or undulating effect upon it than the removal of the ash or clinker, as much of the fire lies dormant on the flat surface of the grate bars.

The water bar type, for many years accepted as the only reliable hard coal grate possessing lasting qualities, allowed no means whatever of shaking down the ashes and the only manner of working the fire was from the surface with a puddling bar and hoe, a very laborious and inefficient operation, especially on long runs when it is apparent that the fire must eventually become so clogged with ashes and cinders as to become practically smothered. This condition is more pronounced with the cheaper grades of fuel. When the wide firebox was first introduced the quality of coal furnished, "buck" and culm, while small and unmarketable at that time, was otherwise good coal and would burn down with a small percentage of ash. Now there is an active market for these varieties and the locomotives are being fed with washed coal from the culm banks, where it has lain for years, and, in addition to the natural deterioration, contains a large percentage of slate and other impurities that the washing does not eliminate.

On the line with which I am connected we have found a combination grate to work well. This grate is part water and part shaking. We retained every alternate water grate and between this longitudinal framing mount sections of finger grates known as the "Yingling" design. These are arranged to be shaken in four divisions and each alternate section in an opposite direction, the fingers engaging in such a manner as to dislodge and carry down all loose ashes and grind to small particles the cinders coming in contact with them, the water bars supporting the body of the fuel in the furnace and preventing excessive disturbance of the surface of the fire. It is evident that the water bars thus arranged afford protection to the finger grates as the latter, although very delicately constructed (the body of the finger being but ⅜ in. thick) seldom break and never burn out, due, no doubt, to the proportion of air space which is more than 40 per cent.

To return to my first proposition, a mechanical stoker. It may be of the Roney type or the Kincade, the latest, or, what would be better yet, the pulverized fuel blower requiring no grate bars or ash pan, only the grinding and blowing mechanism, which might be located low enough in the tender to allow the coal to fall into it by gravity and it is not improbable that means will yet be found for safely handling the ground fuel from the coal house, where the locomotive with a hermetically sealed tank will have a supply blown in in the same manner that a gas or oil tank is filled. All that would then be required would be sufficient air pressure to blow it out again and into the furnace. If the pulverized fuel system is not yet fully developed and mechanical stokers of the ordinary type must be used, then means should be provided to operate the shaking grates by power, as quite an effort is necessary to shake them by means of ordinary hand levers and hand power and their efficiency would thereby be correspondingly reduced, for it is a difficult matter to obtain the necessary attention of the fireman when these conditions exist.

RESULTS FROM TONNAGE RATING,

Southern Pacific Company.

By B. A. Worthington,

In Charge of Tonnage Rating.

An elaborate description of the tonnage rating methods of the Southern Pacific System is contained in a paper by the writer read before the Pacific Coast Railway Club in November, 1900. The results from actual practice in improving the cost of operation are striking and the advantages of the methods are marked. These may be briefly summarized as follows:

Features of This System.

1. All through ratings are based on time and load; local ratings only are based on capacity of power.

2. Engines are classified according to power, and a separate rating is given for each engine according to the number and class, so that no figuring is necessary on the part of trainmen to determine the rating by the class to which an engine belongs.

3. Power of engines is limited by calculated traction at 10 miles per hour, when such traction does not exceed one-quarter of the driver weights. While one-quarter of the driver weight may seem high, yet it harmonizes closely with our practice.

4. Every piece of track in each direction was figured over in the Engineering Department, to arrive at the resistance offered and to determine the load that could be taken at varying speeds, based on the resistance data and energy gained from momentum, as explained in detail in the paper above referred to.

5. In addition to the rating, the rating sheets show, for the information of the dispatchers, the per cent. of load greater than rating that can be taken as a maximum between every two stations in both directions.

6. Time is an important factor with us on our long through lines and in addition to the relative efficiency attained for each train, our daily reports show the actual time consumed, including and excluding stops, enabling us to promptly locate apparently unnecessary delays.

7. A detailed monthly report is made, a copy of which is sent to each division, so that each superintendent may see what all others are doing, and as they are all practically measured with the same "measuring stick" under this system, it naturally prompts those making the poorest showing to make a strenuous effort to improve their performance.

Results Obtained.

In my paper on this subject (pages 206 and 207) I gave the

results of nine tests in actual service, which show how closely the theoretical calculations check with the practice both in point of time and load, on the basis of actual running time, excluding stops. A moment's reflection will suggest that the actual running time, excluding stops, is the true measure upon which the work performed by the locomotive should be judged, as it would be impossible to even approximate the time that might be consumed on sidings, when the engine is performing no service. On one test the variation in time was 13 minutes on a 128-mile run, and in the opposite direction only 9 minutes; another was 15 minutes on a 123-mile run; another 10 minutes on a 124-mile run over a very heavy division, helpers being used in two places, one 12 miles, the most of which is 1.9 per cent. grade and the other 26 miles, 20 miles of which is continuous 1.35 per cent. grade. In another case there was a variation of 4 minutes on a 95-mile run, and another only 24 minutes on a 124-mile run, with a train of 60 cars, 2,500 ft. long, being two-thirds empties, over a heavy division, with few sidings long enough to hold the train.

Daily reports show trains on all runs loaded up to the rating, but the preponderance of tonnage one way or the other naturally brings down the average train load in the opposite direction. Local trains, rated to capacity, usually take all there is to go and pick up and set out cars for intermediate points. These factors prevent the possibility of the general average efficiency showing 100 per cent., yet on very many runs 100 per cent. average is made in the direction in which the preponderance of tonnage runs.

As an illustration of the uniformity of this system of tonnage rating, the reports for the month of February show a variation of only four points—from 81 per cent. to 85 per cent. efficiency—in train load, the rating in each case being taken as 100 per cent., upon the seven divisions of the Pacific System, embracing both hill and valley sections, varying from a level track to 2.2 per cent. gradient on the Sacramento and Tehachapi mountains, and to 3.3 per cent. gradient on the Siskiyou mountains. For March, the average efficiency on the same seven divisions varied from 78.6 to 90 per cent.; for April, from 83 to 91 per cent. As indicative of the gradual improvement being made, the general average of all divisions, including through and local freight, was: January, 77 per cent.; February, 80 per cent.; March, 85 per cent.; April, 86 per cent. efficiency, the rating in all cases being taken as 100 per cent.

The new time-load system of tonnage rating was put in effect on July 1, 1900. Prior thereto the load was based on the capacity of the locomotives reduced arbitrarily to come within the time requirements. The results since that time as compared with last year under the old tonnage rating system, when the performance was exceptionally good, being the best in the history of the company up to that date, have been as follows on the Pacific System lines, as shown by the General Auditor's figures:

	Ton-miles of revenue freight handled.
First 8 months of this fiscal year	2,182,245,387
First 8 months of last fiscal year	1,974,056,226

An increase in volume of 10.5 per cent.

The total mileage of freight locomotives, including those double-heading, or helping trains, or run light in connection with them, was as follows:

	Engine Miles
First 8 months of this fiscal year	8,656,456
First 8 months of last fiscal year	8,621,107

An increase of only 0.4 per cent.

It will be noted that the engine miles increased only four-tenths of one per cent. in moving 10.5 per cent. more ton-miles of freight. The tons of freight moved per engine mile increased from 229 to 252 tons, the saving by heavier loading being equivalent to the movement of 873,000 engine miles in the period in question, or at the rate of 1,200,000 engine miles per annum, which is directly attributable to the new tonnage rating system, coupled with improvements in motive power and constant vigilance on the part of the management, than which there is probably none more efficient in the railway world.

A BOILER-SHELL CHART.*

By Lawford H. Fry.

In determining the strength of a locomotive boiler waist or of any other cylindrical riveted shell subjected to internal pressure the following formula is employed:

$$F = \frac{2\,t\,p\,s}{D\,P} \quad \text{..................(1)}$$

Where

F is the factor of safety desired,

t is the thickness of the plate in inches,

p is the ratio of the strength of the riveted seam to the strength of the solid plate,

s is the ultimate tensile strength of the material in pounds per square inch,

D is the inside diameter of the shell in inches,

and P is the working pressure in pounds per square inch.

In work where this formula is repeatedly used, as for example, in designing locomotive boilers, it is desirable to tabulate the results obtained from the application of the formula to those cases which occur frequently. If the range of work is wide, the tabulation will be laborious to construct and unhandy to use. To take the place of a table and to facilitate all calculations regarding the strength of a cylindrical riveted shell the accompanying chart was constructed. If all but one of the factors of the formula are known the chart will automatically solve the resulting equation and give the value of the unknown factor. Since it does away with calculation it makes for ease, accuracy and rapidity of working.

An inspection of the chart will show that it consists of vertical lines corresponding to the internal diameter of the boiler, horizontal lines corresponding to the thickness of the shell, and a series of scales at the upper right-hand corner. The chart is primarily intended for locomotive boiler shell computations, consequently the scales which correspond to the factor of safety give values from 4 to 6 and a scale is given for each increment of ten pounds per square inch of boiler pressure, for pressures ranging from 140 to 220 pounds per square inch.

To use the chart a straight-edge is laid through the point of origin which is marked at the lower left-hand corner of the chart, and through the required factor of safety mark, the mark being of course chosen on the scale corresponding to the given working pressure. Then the point of intersection of the straight edge with the vertical line corresponding to the internal boiler diameter is noted; the horizontal line through this point of intersection gives the thickness of plate necessary to satisfy the conditions. It will be noticed that there are three series of horizontal lines, drawn for the sake of distinction, heavy, medium and light. Each series of lines corresponds to a type of riveted seam, as may be seen from an inspection of the left-hand end of the chart, where it will be found that the figures giving the thickness of plate are grouped in three columns, headed respectively with the designation of type of seam. Thus the heavy lines correspond to butt seams with sextuple riveting, the medium lines to butt seams with quadruple riveting, and the fine lines to double riveted lap seams.

To ilustrate the use of the chart a line has been drawn through the origin and through the mark for a factor of safety of 5 on the scale of 180 lbs. per square inch boiler pressure. If we wish to determine the thickness of plate for a shell 50 ins. internal diameter to give a factor of safety of 5 with 180 lbs. per square inch pressure, we note the intersection of the above diagonal line with the line of 50 ins. boiler diameter. The point of intersection lies between two horizontal lines. The line above corresponds to a plate ½ in. thick with a quadruple riveted butt seam, and the line below to a 9/16 in. plate with a double riveted lap seam. Either of these two arrangements would give a satisfactory practical solution of the problem. Obviously also if the boiler diameter and thickness of sheet are

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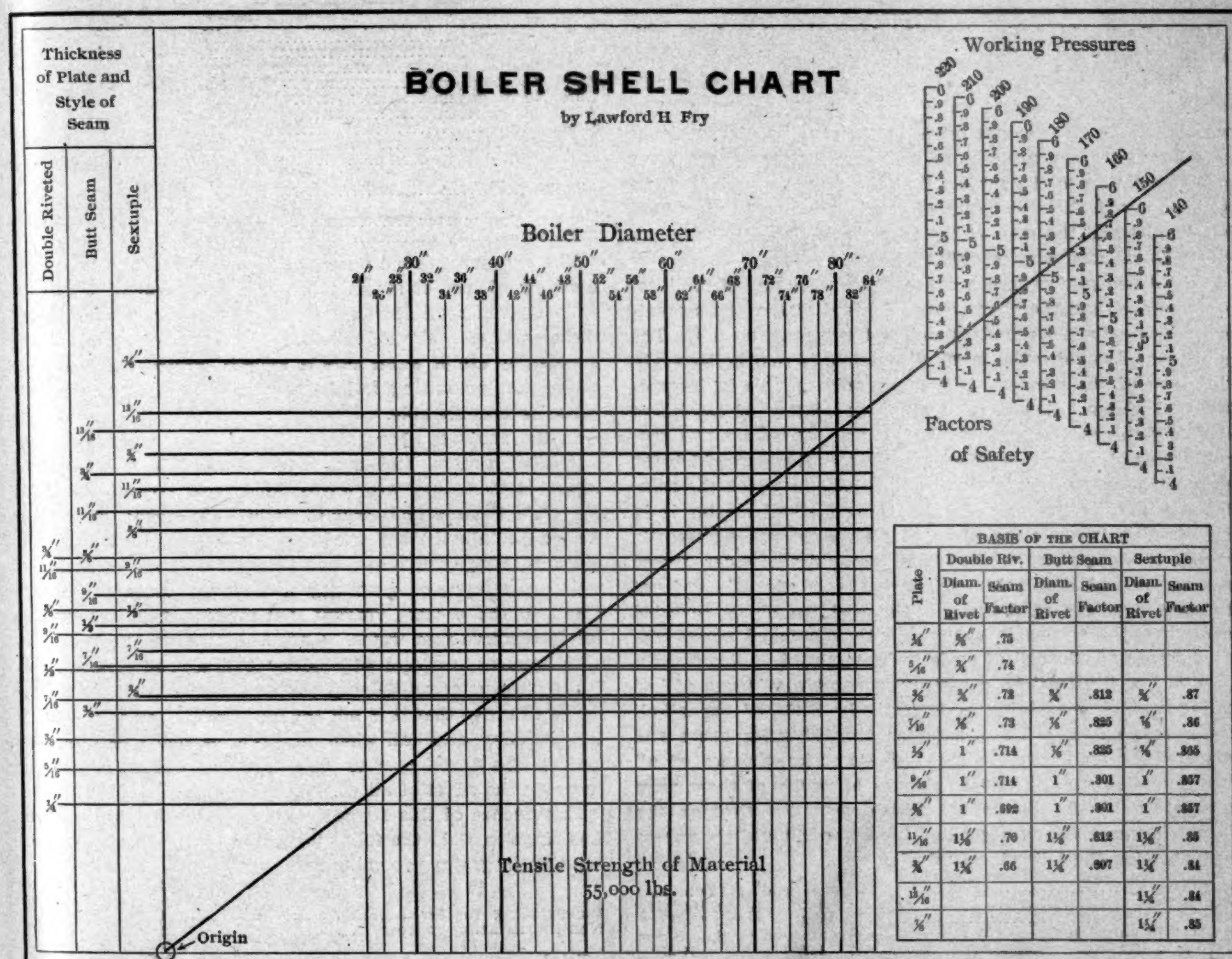
given the chart may be used to determine the allowable boiler pressure. Take, for example, a shell 68 ins. inside, made of 11/16 in. plate with a double riveted butt seam. Find the intersection of the horizontal plate line and the vertical diameter line and lay a straight-edge through this point of intersection and the point of origin, and note where the straight-edge cuts the boiler pressure scales. It will be seen from the diagonal line drawn in the figure that we get a factor of safety of 4.5 for a pressure of 200 lbs. per square inch, a factor of 5 for 180 lbs. and a factor of about 5.62 for 160 lbs. Similarly if the boiler pressure and plate thickness are given the largest allowable boiler diameter can be determined.

The vertical lines are drawn so that the distance of each from the vertical base line, O Y, is proportional to the boiler diameter with which it is marked. The horizontal lines are drawn to a scale so chosen that the distance of each from the horizontal base line, O X, is proportional to the ultimate shell strength corresponding to the plate thickness and style of seam which the line represents. This ultimate shell strength is determined by inserting the particular values of plate thickness (t), and steam factor (p), in the shell strength component (110,000 t p) of equation (3). The various values of the seam factor (p) are given in the table at the lower left-hand corner of the chart. With these two elements determined, the pressure



BASIS OF THE CHART						
Plate	Double Riv.		Butt Seam		Sextuple	
	Diam. of Rivet	Seam Factor	Diam. of Rivet	Seam Factor	Diam. of Rivet	Seam Factor
1/4"	5/8"	.75				
5/16"	3/4"	.74				
3/8"	3/4"	.73	3/4"	.812	3/4"	.87
7/16"	7/8"	.73	7/8"	.825	7/8"	.86
1/2"	1"	.714	7/8"	.825	7/8"	.865
9/16"	1"	.714	1"	.801	1"	.857
5/8"	1"	.692	1"	.801	1"	.857
11/16"	1 1/8"	.70	1 1/8"	.812	1 1/8"	.85
3/4"	1 1/4"	.66	1 1/4"	.807	1 1/4"	.84
13/16"					1 1/4"	.84
7/8"					1 1/4"	.85

In conclusion the basis on which the chart has been constructed will be pointed out. In the first place the ultimate tensile strength of the material is taken at 55,000 lbs. per square inch. The original formula (1) then takes the form:

$$F = \frac{110{,}000\ t}{D\ P}\ p \quad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

or by transposition

$$P\ F = \frac{110{,}000\ t}{D}\ p \quad \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

This expression divides naturally into three components:

(a) pressure component, P F;

(b) boiler diameter, D;

(c) shell strength component, 110,000 t p;

each of which corresponds to one of the elements of the chart. The first step in the construction is to choose appropriate horizontal and vertical scales and draw in the corresponding lines as follows.

scales are located in a convenient position by calculation and measurement from the lines established.

Mr. Angus Brown has resigned as Master Mechanic of the Chicago Terminal Transfer Railroad Company to accept the position of Division Superintendent of Motive Power of the New York Central at West Albany.

Mr. S. P. Bush has resigned as Superintendent of Motive Power of the Chicago, Milwaukee & St. Paul to become General Manager of the Buckeye Malleable Iron & Coupler Company, Columbus, O. Mr. Bush is 37 years old and a graduate of Stevens Institute of Technology. His railroad experience began in 1884 with the Pennsylvania Lines Southwest System, where he remained until 1890. The last six years, from 1893 to 1899, he was Superintendent of Motive Power of that road, which position he left to go to the Chicago, Milwaukee & St. Paul.

SOME PHASES OF THE WATER TREATING PROBLEM.

By Howard Stillman, M. A. S. M. E. and Am. Ry. M. M. Assn.

Engineer of Tests, Southern Pacific Company.

The subject of water treatment for locomotive use in modern railroad service is one that has some very interesting phases. While the principle of water treatment by chemical precipitation seems to be the best method for reduction of scaling and corrosive matter and it is true that such a method readily accomplishes the desired result, there are some side lights on the action of water in locomotive boilers which a practical study of the subject brings out.

Generally speaking, the class of information that deals with the chemistry of water and laboratory practice does not come from those having experience on the footboard. Men who handle the throttle rarely know anything of chemistry. The two classes of men do not cross in their paths of experience and their lines are not apt to converge, yet there are some matters relating to the subject that the writer would draw attention to from the standpoint of one in position to view both the chemist and the man at the throttle. What I have to say relates to railroad service only.

Probably no subject to-day concerns the economy of the locomotive more than the character of its feed water. Some matters relating to it we understand and some we do not. The main point I would make in my discussion, is that boiler scale, while one of the greatest, is not our only trouble in locomotive feed water. Before taking up the matter of treatment let us define what we mean by bad water. There are two general classes of water that affect the service: those in which the incrustating matter predominates and those in which the soluble, non-incrustating or generally termed alkali matter is in excess. The incrustating class of waters do not necessarily trouble the engineer as they may act quietly under forced evaporation and enable him to work a good throttle and get his train over the road easily. The real trouble is revealed only when the engine is shopped with a cracked plate, corroded flues and "loads" of scale to be removed.

I give two illustrations constituting notable evidence of bad scaling waters containing comparatively little of the alkali matter referred to. These supplies are 466 miles apart and separated by an entire division. Systematic analyses of all water supplies gave the first evidence of which of them were making trouble in the boilers which were put through the shops. Locomotive engineers had for years believed the waters good, showing the following analysis:

Station	Casa Grande.	Saugus.
Location	Arizona.	California.
Source	Well.	Well.
Matter in solution.	Grains per U. S. gallons.	
Carbonate lime	4.08	11.37
Sulphate lime	32.08	23.50
Chloride lime	8.28	.....
Carbonate magnesia	2.45	1.46
Sulphate magnesia	.....	17.15
Chloride magnesia	7.81	.....
Alumina and iron	.29	.12
Silica	4.49	1.69
Sulphate soda	.....	14.84
Chloride soda	18.34	2.22
Total	77.82	71.85
Total incrustating	59.48	55.29
Total non-incrustating	18.34	16.56

The above waters are extreme types taken in illustration, and the question I would ask the chemist whose opinion is based on laboratory experience is, why did not the above waters give road service trouble from foaming and priming, if the alkalies do not cause foaming as is a stated opinion followed by the expression "boiler foaming takes place only in the presence of particles of matter suspended in the water in the boiler." It was apparent that the above waters did deposit a large quantity of matter in the boilers without foaming. It has also been written that in the laboratory, experiments have been made with boiling solutions of different qualities to induce foaming. Experiments with distilled water under conditions so far removed from practice I do not consider of value. The conditions of forced steam production in the locomotive boiler under influence of pressure and corresponding heat cannot be readily reproduced in the laboratory.

Passing now to the matter of effect of water of the second general class I have referred to, namely, those containing the alkalies in excess (salts of soda and potash). I would illustrate the following waters that have been notorious for years as causing great trouble and expense from foaming and priming at the Tucson Division in Arizona, but without evidence of excessive formation of scale in the boilers shopped.

Station	Yuma.	Adonde.	Gila Bend.
Source	Colo. R.	Well.	Well.
	Matter in Solution, grains per U. S. Gallon.		
Carbonate lime	7.58	10.44	4.37
Sulphate lime	2.85	1.40	11.08
Chlorate lime	.....	.....	4.37
Carbonate magnesia	.75	2.56	.70
Sulphate magnesia	2.80	6.42	.....
Chloride magnesia	.....	.93	2.51
Alumina and iron	2.33	.17	.41
Silica	1.11	1.69	1.22
Sulphate soda	13.64	.....	.....
Chloride soda	17.66	47.12	60.65
Total	48.78	70.73	85.31
Incrustating matter	17.42	23.62	24.31
Non-incrustating matter	31.30	47.12	60.65

The expense to road operation in loss of fuel from constant blowing off, use of steam more or less saturated in cylinders and delay in road service have been considerable from use of these waters. The Adonde and Gila Bend waters are now avoided by use of water cars in freight service, carrying better water. At prevailing freight rates, however, this item of expense is considerable.

In the analyses above shown I have taken extreme cases of untreated waters, and my judgment in regard to them, as types, is that they are untreatable with commercial profit; the Casa Grande and Saugus waters, by reason of the large amount of alkali that would result from a reduction of the scale forming sulphates and chlorides they contain; the Arizona waters would not pay to treat by reason of additional alkali to the present amount that renders them unserviceable for locomotive feed water. I firmly believe in the theory that alkali matter in excess will induce foaming and priming. Matter in suspension will also produce this result, but there is evidence to prove that it is not the only cause. As to treated water, the effect of alkali when increased beyond a certain degree by reaction together with that naturally contained also goes to prove the effect of alkali.

In evidence of this I would quote the treated water at Port Los Angeles, Cal., the following being the matter contained in solution in grains per gallon:

	Before treatment.	After treatment.
Incrustating matter	39.24	10.04
Non-incrustating matter	12.31	33.63
Total	51.55	43.67

This water is supplied to a long wharf at which coal is loaded and shipped by rail, the road following along shore a few miles, then ascending a short, steep grade to the top of a bluff. In hauling coal trains to Los Angeles it is customary to take a "run" at the short grade, the summit being attained with the lever well down and full open throttle. Before treatment of the water the run was easily made without priming. After treatment the water was "light" under this severe test; a shower of water from the exhaust would follow the rapid demand for steam and the method of "doubling" the hill had to be followed. This led to so much trouble that the extent of treatment was reduced by diminishing by one half the amount of soda ash used. The result is a partly treated water showing the following matter in solution by most recent analyses:

	Before treatment.	After treatment.
Incrustating matter	42.88	20.41
Non-incrustating matter	13.24	26.48
Total	56.12	46.89

The present treated water does not form scale large in amount though the matter classed as incrustating by analysis

shows 20.41 grains per gallon, of which amount 15.05 grains are magnesium sulphate.

This brings us to another phase of the problem: To what extent does magnesium sulphate form scale after the carbonate and sulphate of lime are removed? At San Luis Obispo the treated water contains about 14 grains per gallon of magnesium sulphate with the carbonate of lime reduced to 2 grains, and sulphate of lime, none. The treated water does not form scale or corrode at this point. The total alkali amounts to 12.95 grains per gallon, which amount does not cause priming. When treatment was first established at San Luis Obispo an attempt was made to eliminate the sulphate of magnesium using 2½ lbs. of soda ash for 1,000 gals. The result was as desired, but the water primed so badly that the soda ash was reduced to 1½ lbs. The treating plant at San Luis Obispo has been in operation about three years.

In regard to the action of magnesium sulphate in natural water containing carbonate of lime in excess as usually occurs, I am confirmed in the belief, by continued experience, that it does decompose under the influence of high steam pressures and heat in boilers to produce lime sulphate and magnesium oxide. Some authorities class magnesium sulphate as non-incrustating.

To sum up the matter presented, I would urge the necessity of letting the left hand know what the right hand is doing in the matter of water treatment else the effectiveness of the locomotive may be impaired and this may become more important than the cost of repair from excess scale and corrosion.

I most certainly advocate the treatment of boiler waters for removal of excess scale and corrosive matter, but the limits I would prescribe are as follows:

Do not ordinarily attempt to treat a water containing less than 12 grains per gallon of total matter classed as incrustating unless of an unusually corrosive nature such as the unstable chlorides of lime and magnesium.

It is not commercially profitable, ordinarily, to treat a water if the total alkalies (salts of soda or potash) naturally contained and resultant, exceed 30 grains per gallon.

As above stated, I have confined my remarks to water for locomotive use only. The conditions of stationary practice are very different as I may illustrate from service tests at some future time.

A monster 16-in. army gun has just been completed at the Watervliet arsenal that surpasses the guns of the world in range. The noted Krupp gun recently tested in the presence of the German Emperor dropped a shell eleven miles from its initial point, but the American gun will shoot nearly 10 miles farther; its range being about 21 miles. This gun, which is to be on exhibition at the Buffalo Exposition, weighs 130 tons, is 49 ft. 2.9 in. long, with a rear diameter of 5 ft.

BEST TYPE OF ENGINE FOR HEAVY FAST PASSENGER SERVICE.

By F. F. Gaines,

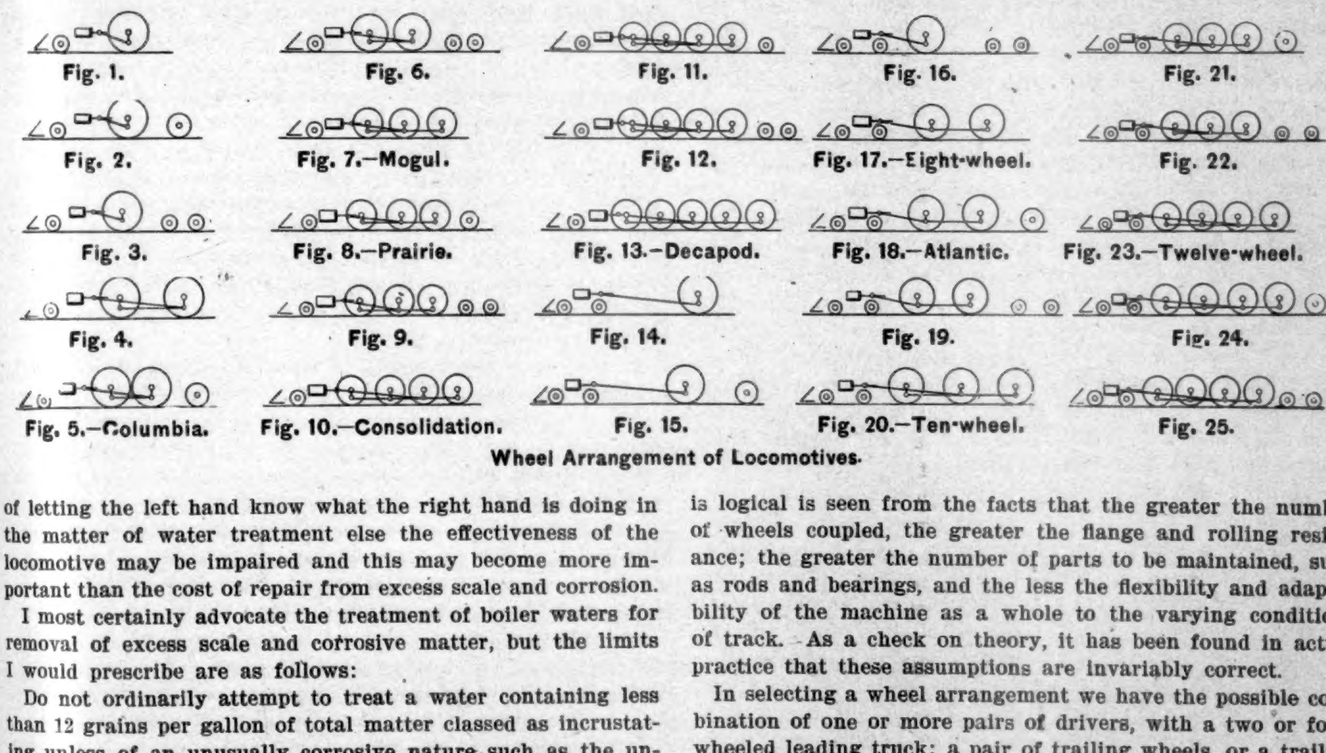
Mechanical Engineer, Lehigh Valley Railroad.

The best type of engine, as regards wheel base arrangement, for any given road or run, depends upon the conditions under which it is to be operated. The length and weight of train, the speed, grade and curvature are all important factors in deciding this problem. The duration of grade, as well as the rise, also affects it. On runs where a large percentage of the distance is level or nearly so, with a few miles of heavy grade intervening, it is questionable if an engine powerful enough to handle the train on the grade should be selected. It would seem to be more economical, when track, maintenance of power, etc., are all considered, to select an engine that will do the work properly on the level, using a helper for the grade.

As a general proposition, or even as an axiom, it may be stated that the smaller the number of coupled wheels used, the faster the engine will run, and the less the cost of repairs for a given mileage—all other things being equal. That this is logical is seen from the facts that the greater the number of wheels coupled, the greater the flange and rolling resistance; the greater the number of parts to be maintained, such as rods and bearings, and the less the flexibility and adaptability of the machine as a whole to the varying conditions of track. As a check on theory, it has been found in actual practice that these assumptions are invariably correct.

In selecting a wheel arrangement we have the possible combination of one or more pairs of drivers, with a two or four-wheeled leading truck; a pair of trailing wheels, or a trailing truck. Several of these arrangements are shown in Figures 1 to 25 inclusive.

For high-speed passenger engines considerations of safety debar all arrangements having a two-wheeled leading truck, unless its use is an absolute necessity, due to unusually favorable circumstances. Running at high speed, the leading truck guides, or should guide, the engine. When entering a curve the side pressure on the wheel flanges is enormous, the pressure having a tendency to cause the wheel to mount the rail. The greater the weight on the truck, the greater will be the resistance to this tendency, and obviously a four-wheeled truck can safely carry twice as much weight as a two-wheeled truck, thereby doubling the probability against derailment. In these times when the legislative public is closely investigating and legislating against all features and devices that are not acknowledged the safest and best, it behooves those concerned to select only the safest devices as a precaution against possible future changes compelled by law. The four-wheeled leading truck is much more conducive to easy riding



Wheel Arrangement of Locomotives.

of the engine, as well as the lessening of oscillations at the front end, which throw a certain amount of stress on the machinery. If the side play of a two-wheeled truck is made stiff enough by springs or other arrangements to prevent these oscillations at high speeds, and when entering curves, the side thrust on the wheel flanges rises to a point where it becomes dangerous—dangerous as regards resistance of the material in the flanges against fracture and the mounting of the rail by the wheel at a low joint or other imperfection in the track. If, on the other hand, the side play is sufficiently easy to keep the flange pressure within safe limits, on any but very straight track, there is a probability of the truck not being able to do all the guiding, throwing part of this duty on the first pair of drivers, with the probable result of abnormal flange wear. From motives of both safety and economy it would seem advisable to exclude any arrangement having a two-wheel leading truck, if it is possible to use any other arrangement. These considerations dispose of Figs. 1, 2, 3, 4, 5, 6 and 7.

On account of the extra number of parts involved, and the fact that there is little or no necessity for their use, as regards carrying capacity, the use of four-wheeled trailing trucks need not be seriously considered. This excludes Figs. 9, 12, 16, 19, 22 and 25. The arrangements shown in Figs. 14 and 15 are not such as to carry a boiler of sufficient power. Of the remaining numbers, Figs. 10, 11, 13, 23 and 24 are too heavy and cumbersome for anything but very heavy trains on heavy grades, and could not be operated on account of their lack of flexibility at high speed. This series of eliminations leaves Fig. 8, or "Prairie" type; Fig. 17, or eight-wheel "American" type; Fig. 18, or "Atlantic" type; Fig. 20, or ten-wheel type, and Fig. 21, an unnamed type, for further consideration.

On account of the considerations previously mentioned, the best engine for any service will be that which with ample boiler capacity and sufficient adhesion or weight on drivers will have the smallest number of wheels, and consequently be the simplest. In this respect the eight-wheel, or "American" type, shown in Fig. 17, is unquestionably the first choice if the boiler can be carried by the wheel arrangement without overloading the journals, or giving too high a concentrated wheel load, the latter being governed by the physical condition of the track and bridges on the line. The "Atlantic" type easily comes second, as it has the same flexibility and a small number of parts, with the added advantage of much greater boiler capacity. Up to the point where it becomes a question of adhesion, in connection with a heavy drawbar pull on long, steep grades, it is a powerful type of engine which is capable of handling heavy trains at a high speed. When more adhesion than can be obtained from the weight on two pairs of drivers becomes necessary, the choice lies between the ten-wheel and "Prairie" types. The use of the latter, with a two-wheel leading truck and a short main rod, can only be justified by unusual conditions. The ten-wheeler has all of its advantages, and none of its disadvantages. Fig. 21 shows a type which, so far as I know, is not in existence. It may, however, be one of the familiar types of the future. It has some disadvantages in the long total wheel base, but it combines great boiler capacity with a well-distributed rail weight, which is often necessary on account of bridges. It would seem to be an ideal type for very heavy mountain service, heavy express or excursion trains, where a consolidation engine is sometimes necessary.

The question of choice of type becomes an easy one when the service conditions are known. A boiler with the proper ratio of maximum horse-power required, to total heating surface; with the proper ratio between flue heating surface and firebox heating surface; a grate area proportioned for the successful burning of the class of fuel to be used should be carried on a wheel arrangement that has the smallest number of coupled wheels that will provide the necessary traction and will not overload the journals or give too high a concentration of rail load. From the foregoing the order of choice is as follows:

1. Eight-wheel type.
2. "Atlantic" type.
3. Ten-wheel type.
4. Type shown in Fig. 21.
5. In exceptional cases, the "Prairie" type.

It should be borne in mind that the objections to a two-wheel leading truck for fast passenger service do not hold good for an engine in freight service, as the circumstances are more favorable in the latter service.

PATENTS AND RAILROAD MECHANICAL DEPARTMENTS.

By J. Snowden Bell.

So much unnecessary litigation and expenditure have been brought about by patent claims on railroad devices that have been proved to be untenable, and so many worthy and original inventors have been sorely disappointed in their hopes of reward for what they have produced, that a general suggestion of what should be done before the question of a patent arises at all may be of some value.

The writer has found, in an extended experience in connection with the procuration and litigation of patents, that in very many cases, and specially as relating to railroad appliances, patents have been granted without any knowledge whatever, on the part of the Patent Office examiners, of what has been previously put into practice, and has not happened to be brought to their knowledge by publication or otherwise. The information of these officers is limited to what has been published, or which, if not published, they may have accidentally noticed. It is therefore entirely reasonable and proper for them to grant a patent for something which, although otherwise patentable, may have been in actual and practical service much longer than would bar the grant, but which has not been recorded in print or otherwise been made known to them.

On the other hand, there are numerous instances in which a person who has made an invention which is both a useful and a valuable improvement, and which has not been known to or used by any other person before his invention, is denied a patent, either because someone else who has obtained knowledge of it, and who is sufficiently dishonest and unscrupulous, has been shrewd enough to get ahead of him on mere technicalities, or by unreliable testimony, or because he has failed to take the proper precautions to fix the date of his invention, or to apply for a patent within the time limited by the law.

The remedies for both classes of cases seem to be simple and easy, and, while they need be stated only in general terms, they are of ready application and easy to understand. It is probable that, if they were universally applied, both the railroad associations and the patent lawyers would, to a considerable extent, be in position to feel, with Othello, that their occupation was gone, yet their loss, whether great or small, would be the gain of many, and this is the purpose we are seeking to promote.

Very many, if not nearly all, of the worthless patents under which unfounded claims of infringement have been made and may hereafter be made, against railroad companies, would never have been issued at all, and would not be issued in the future, if greater attention was paid by the officers of railroad mechanical departments and manufacturers of railroad appliances to the keeping of full and accurate records of all facts and dates relating to the origination and introduction into their service of new designs and appliances, and to bringing them, after they have been put into service and been found to be useful and practical, to the knowledge of those interested in the subject, through the medium of illustrated descriptions in print. The columns of the various railroad journals are always freely open to them for this purpose, and publications of the character referred to are both interesting and instruc-

tive. On general principles this course would obviously be desirable, and, for the purpose of establishing a barrier to the grant of patents for that which should not be patented, it is of direct and substantial value to railroad companies. It may be objected by those unfamiliar with the law, that the inventors of such designs as are really new and patentable, would, by publication, be debarred from protection for them, but such an objection is not a sound one.

The law allows an inventor two years after the date at which he has put his invention into public use, within which to make application for a United States patent on it, and, so long as he does not exceed this statutory limit, the publication of its successful reduction to practice acts in the direction of supporting his claims whenever he is prepared to make them. It is, however, to be noted that under the apparently unreasonable provisions of the patent laws of Europe, a prior publication in this country prevents a valid patent there, but it is only in exceptional cases that European patents are profitable, and the American inventor will, as a rule, find it to his interest not to spend his money on them.

The days in which a narrow-minded policy induced builders of machinery to refuse illustrations of their work to the general public are happily past, and, in most cases, the railroad or private manufacturer who gets out something new no longer wants to hide his light under a bushel. A little of the old leaven, however, remains, and the sooner it is done away with the better. When a locomotive, car, or any other appliance of new design, whether good or bad, goes on the road, it does not fail to attract attention. A two-foot rule, pencil, and sketch-book in the hands of a good draughtsman will easily get all its visible features and those that are closed up can generally be discovered. If the railroad and private shops will publish their new designs they will insure that they are put before the public in the form in which they ought to be presented, will receive the credit for them to which they are entitled, and will block the way of the patent sharp who otherwise might seek to appropriate them and fraudulently obtain a patent with which to carry on a campaign of blackmail.

The other branch of the case is that of the railroad employee who may make an invention. All new and useful improvements are not necessarily patentable ones, but as regards those that are, it is as much to the interest of the railroad company as to that of the employee, that the latter should receive the protection he is entitled to. If the improvement is valuable to the company, the company will ordinarily be glad to pay for it what it is believed to be worth. If it is not, the inventor is not harmed, but in either case the fraudulent patentee and would-be blackmailer has no opportunity.

The railroad man who makes a new design, or what he believes to be a new invention, should be careful to date all his sketches, drawings and written matter relating to it, and should make notes of his movements in the several stages of progression toward its actual use. He should keep his records in such shape as to be able to prove at a later day, if proof should happen to be required, what he did, when he did it, and who took part in, or had knowledge of, his work in the matter. If the design proves, in practice, to do so well as to lead him to believe that it would be to his interest to get a patent on it, he ought to apply for a patent within two years after it has been put in public use, and, indeed, as soon thereafter as his means will permit. He should not waste his money in filing a "caveat" (which is worse than useless) and should be on his guard against incompetent "cheap John" patent solicitors and pretended patent "brokers," who will do nothing but get a fee out of him for putting his patent on their alleged agency books, and who, in nine cases out of ten, are barefaced swindlers, who have been more than once exposed. The division Master Mechanic, or the Superintendent of Motive Power will, in most cases, be able to recommend some competent and trustworthy patent solicitor, and the solicitor will obtain his patent for him, if the invention proves to be patentable, in regular course.

Delays are dangerous in these matters, and the inventor should also recognize that a patent is not necessarily a mine of wealth. It will not have cost him very much beyond the exercise of his ingenuity, and if he receives a fairly good offer for the patent when obtained, it is usually good policy to accept it. If the purchaser makes a profit (as he naturally expects to do), it is because he has facilities for dealing with the property which the inventor does not have, and in most cases would never be able to obtain, and it may be safely said that, in any case, the inventor will do better by devoting his attention to his regular line of work, and to the development of further improvements in it, than by speculating in patent property or dealing with it to a sufficient extent to interfere with the work or business which gives him his living.

GRATE AREAS FOR BURNING CULM.

By T. S. Lloyd,

Superintendent of Motive Power, Delaware, Lackawanna & Western Railroad.

In the use of the small sizes of anthracite coal we have found it worth while to give careful thought to the grate areas in order to permit of using as much as possible of the finer sizes such as the Nos. 1, 2 and 3 buckwheat, which are ordinarily known as buckwheat, birdseye and rice. These are by no means inferior fuels, for they contain the best of anthracite coal and are remarkably free from slate, the only problem is to furnish grate area sufficient to burn the amount of fuel required to do the work of the engines. While a little soft coal mixed with the anthracite is equivalent to a corresponding increase in grate area our efforts have been directed toward an entire elimination of bituminous coal in the anthracite engines. Large grate areas are necessary with fine coal because it runs like sand and in a deep bed leaves no interstices for air. Our object is to reduce the fuel cost by employing 62-cent coal in place of that which costs $2.04 per ton. These are relative figures only and give the proportionate rather than the exact cost. On certain classes of engines now running (having a ratio between total cylinder volume and grate area of less than 9 to 1) we find it necessary to use about 10 per cent. of soft coal, but all of the new classes of anthracite engines use nothing but anthracite. In freight service we use No. 1 buckwheat; in switching service, Nos. 2 and 3 buckwheat, and in heavy passenger service, pea coal. The strong draft of heavy passenger service will not permit of using the finer sizes. The fine sizes are all "washed" coal taken from the culm banks and known as culm. For all new anthracite burning engines shaking grates are used, the change from the water bar grates having been most satisfactory.

We have grades averaging 80 ft. per mile, 25 miles long and 75 ft. per mile 10 miles long, with numerous other smaller slopes. Four new classes of engines have been designed for our service, the switch engine, illustrated in the American Engineer, March, 1901, page 91; an 8-wheel passenger engine, illustrated in May, 1901, page 144; a consolidation freight engine with grates 9 ft. wide and 10 ft. 6 ins. long and a consolidation engine with a moderately wide grate for soft coal. The first three of these are for hard coal, and while the heating surface is, of course, an important factor, we find that it is to a certain extent secondary to the selection of the proper grate area, as far as our immediate object is concerned. With fine coal no amount of heating surface will compensate for the lack of sufficient grate area, whereas if the grate area is right the size of the cylinder part of the modern boilers permits the introduction of sufficient tubes to insure liberal heating surface.

The first engine on this road having a wide firebox over drivers and designed to burn fine coal, was the "New York,"

old No. 102. The boiler was built in these shops, at Scranton, in 1879. The firebox was what was known as the "Swallow Tail" type, the shell of the firebox tapering down at the back to within 8 ins. of the crown sheet. The firebox was 7 ft. wide by 8 ft. 6 ins. long, giving a grate area of 59.5 sq. ft. The ratio between the total cylinder volume in cubic feet and the grate area in square feet was 8.4 to 1. The cylinders were 18-in. diameter by 24-in. stroke and when the cylinders had been bored to 18½ ins. the ratio decreased to 7.9 to 1. This engine burned fresh-mined buckwheat coal successfully, but when the cylinders had been increased to 18½ ins. in diameter, the steaming qualities of the engine were noted to deteriorate. On subsequent engines built of this type with 18 x 24-in. cylinders, we increased the size of the fireboxes to 7 ft. 6 ins. x 8 ft. 6 ins., and later to 7 ft. 6 ins. x 9 ft. and finally 7 ft. 6 ins. x 9 ft. 6 ins. The 7 ft. 6 in. x 8 ft. 6-in. firebox gave a ratio of 9 to 1. The ratio for the 7 ft. 6 in. x 9-ft. firebox was 9.56 to 1, and the 7 ft. 6 in. x 9 ft. 6-in. firebox gave a ratio of 10 to 1.

When we built the first 19 x 24 mogul in 1882 of the wide firebox type we made the ratio 9.06 to 1, the firebox being 7 ft. 6 ins. wide by 9 ft. 6 ins. long. These engines steamed so well that this firebox was adopted as a standard for 19 x 24-in. freight engines, but on 19 x 24-in. passenger engines we increased the size of the firebox to 8 ft. wide by 10 ft. long. This gave us a ratio of 10 to 1. Our first passenger engines having wide fireboxes had Wootten combustion chambers. In 1894 as an experiment we cut out the combustion chambers on all but a few of our passenger engines, with satisfactory results.

Our first 20 x 24-in. consolidation engines had fireboxes 7 ft. 6 ins. wide by 9 ft. 6 ins. long. This gave a ratio between the total cylinder volume and the grate area of 8.1 to 1. We increased the size of the fireboxes on some of these engines to 8 ft. wide by 10 ft. long, or a ratio of 9.17 to 1, and the alteration made a great improvement in them. As we went into heavier power with increased cylinder capacity, we found it difficult to keep up the proper ratio between grate area and total cylinder volume. Ten feet was considered a proper limit for the length of fireboxes and the limit of width of the engines was established at 9 ft. 4 ins. In 1893 we built a 10-wheel engine with 63-in. drivers for fast milk-train service. As this engine was expected to make fast time with heavy trains we decided to design a firebox with a very liberal grate area. We made the firebox 8 ft. 4 ins. wide by 10 ft. long, giving 83 1/3 sq. ft. grate area and a ratio to cylinder volume of 9.5 to 1. The firebox was 9 ft. 4 ins. wide outside of the lagging, which was then our limit. This engine proved to be an excellent steamer. Our new consolidation engines of the wide firebox type have 21 x 26 cylinders. To make the ratio of the cylinder volume to the grate area equal to our standard ratio, we made the firebox the extreme limit in width that would insure clearance on the road, or 9 ft. wide inside and 10 ft. 6 ins. long inside. This grate area is 94.5 sq. ft. and gives a ratio of 9.4 to 1. This ratio will insure splendid steaming qualities. Our new 8-wheel passenger engines with 20 x 26 cylinders have fireboxes 8 ft. 4 ins. wide and 10 ft. 6¼ ins. long, with a grate area of 87.67 sq. ft., and a ratio of 9.3 to 1.

The increase in the ratio of the total cylinder volume to the grate area on this type of engine has been with us a gradual evolution covering a period of twenty years. We have found in actual practice that with a ratio of 9 to 1 our engines prove free steamers without the use of any bituminous coal; other roads introduce 40 per cent. and even as much at 65 per cent. of bituminous coal on account of insufficient grate area. The large grate area not only permits of the successful consumption of the finer and least valuable commercial sizes of coal, but absolutely abolishes the emission of smoke, which cannot be done where grate areas are contracted and bitumi-

FUEL TESTS OF 8-WHEEL LOCOMOTIVE NO. 980, DELAWARE, LACKAWANNA & WESTERN RAILROAD.

CONDUCTED BY STUDENTS OF CORNELL UNIVERSITY.

TEST NUMBERS.	1.	2.	3.	4.	5.
FUEL—POUNDS.					
Consumed on run	13,655.0	9,926.0	10,500.0	10,65[illegible].0	13,000.0
Consumed per hour while running	4,670.0	2,890.0	3,640.0	2,900.0	3,900.0
WATER—POUNDS.					
Total evaporated on run, lbs	67,100.0	54,600.0	55,400.0	69,700.0	69,000.0
Water evaporated per hour, lbs	23,000.0	18,500.0	19,200.0	18,800.0	20,780.0
Equivalent evaporation from and at 212° F. on run.	82,300.0	66,700.0	67,600.0	81,700.0	84,200.0
Equivalent evaporat'n from and at 212° F. per hour.	28,180.0	22,600.0	23,400.0	23,000.0	25,190.0
Boiler, h.-p	819.0	656.0	680.0	668.0	736.0
ECONOMIC EVAPORATION.					
Water evaporated per lb. of coal on run	4.98	5.5	5.28	6.55	5.3
Equivalent evaporation from and at 212° F	6.12	6.72	6.45	7.95	6.47
RATE OF COMBUSTION.					
Coal burned per sq. ft. grate per hour	53.3	33.0	41.5	33.19	44.6
RATE OF EVAPORATION.					
Water evap. per sq. ft. heating surface per hour	10.7	8.61	8.95	8.82	9.25
Water evap. from and at 212° F. per sq. ft. heating surface per hour	13.1	10 55	10.9	10.71	11.28
Sq. ft. heating surface per h.-p	2.62	3.27	3.15	3.21	2.92
TRAIN DATA.	April 26.	April 27.	April 29.	May 2.	May 2.
Between Scranton and Hoboken	East. Day.	East. Day.	East. Day.	East. Day.	West. Night.
No. of cars	1 Pullman 3 coaches 1 com. smoker and baggage.	1 Pullman 2 coaches 1 com. smoker and baggage.	1 Pullman 2 coaches 1 com. smoker and baggage.	1 mail 1 express 1 coach 1 Pullman 1 smoker 1 dining car Strandsburg to New York.	4 Pullmans 1 coach 1 smoker 1 express
Estimated weight of train—tons of 2,000 lbs	193 T.	148.0 T.	148.0 T.	212 T.	276 T.
Average steam pressure while running	177.5	182.5	180.2	153.3	182.0
Average temp. smoke box while running, F	725	830	943	......	......
Av'ge smoke box vacumn while run'g, ins. water	5.5	6.1	6.03	......	......
Average temp. feed water, F	45	48	50	50	48
Average speed, M. P. H., not including stops (integration of speed recorder roll	44.0	43.0	......	......	......
Average of maximum draw bar pulls, lbs	4,200.0	3,990.0	......	......	......
Average (A) of maximum indicated h.-p	832.0	936.0	......	......	......
Average of maximum dynamometer h.-p	405.0	458.0	......	......	......
Ratio $\left\{\frac{\text{dynamometer h.-p.}}{\text{indicated h.-p.}}\right\}$	.487	.48	......	......	......
Average quality of steam in dome while running	95.2%	94.9%	......	......	......
Average quality of steam in chest while running	96 4%	95.6%	......	......	......
Average quality of steam while standing still.	98.5%	98.5%	......	......	......
Time on road	4 hrs. 1 min.	3 hrs. 53 min.	3 hrs. 53 min.	4 hrs. 33 min.	4 hrs. 10 min.
Running time	2 hrs. 55 min.	2 hrs. 57 min.	2 hrs. 53 min.	3 hrs. 41 min.	3 hrs. 20 min.
Drifting and stops	1 hr. 6 min.	0 hrs. 56 min.	1 hr. 0 min.	0 hrs. 52 min.	0 hrs. 50 min.
Condition of weather	Fine Day.	Fine Day.	Fine Day.	Cloudy.	Rained HARD.
Condition of rail	Dry.	Dry.	Dry.	Dry.	Slippery.

nous coal is permitted to be used even with a small percentage.

The report of the committee on grates in the Master Mechanics' Association proceedings of 1897 recommends this ration of 9 to 1 for fine anthracite fuel. The report is a consensus of opinion formulated through the experiences of this and other roads using fine anthracite fuel. A representative of one of our neighboring roads after a tour in 1894 of all roads using this fuel, stated in his report that the D., L. & W. was the only road burning fine anthracite coal on locomotives without the use of any bituminous coal.

We consider a ratio of 9 to 1 a minimum limit for fine anthracite coal for road service without a mixture of bituminous coal and as the ratio is increased the size of fuel can be decreased. We also find that as the ratio is increased a poorer quality of coal can be successfully burned. On engines engaged in switching service we find with a ratio of 8.6 to 1 that fine anthracite coal of the smallest sizes can be successfully burned without bituminous coal, as the conditions are different on these engines from those of road engines, the runs being short, large nozzles can be used and the draft effect on the fire is modified, not being as severe as on road engines operating on our heavy grades.

I include a record of recent tests on one of our passenger locomotives conducted by Mr. A. S. Tourison, Jr., assisted by other students of Cornell University. This was done in connection with a graduating thesis. The record of maximum indicated h.p. marked (A) when averaged, did not include cards taken while drifting. The water was measured by a calibrated meter and checked by tank readings. The coal was weighed on truck scales.

SHOULD ENGINE TON MILEAGE BE INCLUDED IN MOTIVE POWER STATISTICS?

By C. H. Quereau,

Assistant Superintendent Motive Power, Denver & Rio Grande Railway.

It is not necessary to make an extended argument to show that railroad managers consider statistics essential to the successful management of the properties they control, but until within a few years the careful study which its importance warrants has not been given to the basis of these statistics, or the units by which the operation of railroads are judged and controlled. While it is admitted that statistics are essential to the highest success, it is equally true, though not universally recognized, that they may easily be misleading and result in incorrect conclusions or poor operative results, either because the basis of comparison is a false one or because some essential items have been omitted.

Until recently the capacity of locomotives has been determined by the number of cars they were rated to haul. This unit has been quite generally abandoned because of the varying weights of cars, and instead locomotives are now rated by tons. Experience has shown that the use of the ton basis for moving traffic has resulted in increased train loads and fewer delays, increasing the net earnings and it can be shown that the reason for this greater efficiency of the locomotives is the fact that the ton is a more accurate measure than the car of their capacity to do work.

Comparisons based on the car are very liable to be misleading because there is no standard car and no uniform weight of lading for a car. An increase or decrease in the average weight of the cars handled during any number of years, which are to be compared for the purpose of determining whether an improvement, or the reverse, has been made, results in wrong conclusions. If the average weight of the car and its lading is less than during the period compared with, there appears to be an improvement, while in fact there is not, but rather the reverse. But if, as is more probable, the average weight per car has increased, the showing will be less favorable, notably in the cost of delayed time, locomotive fuel and repairs, and the facts are, that instead of less favorable results, there has been an improvement, statistics to the contrary notwithstanding, because there is always a decrease in operating costs when the train load is increased, so long as the increase does not result in excessive delays. When the basis of operating is the ton the liability of such wrong conclusions largely disappears, because the ton is a constant unit of weight, and its usefulness is not seriously affected by variations in the weight or capacity of cars. In short, the ton is a more accurate measure of resistance than the car. Notwithstanding these facts, which seem self-evident when attention is called to them, a number of railroads still judge operating results by the number of cars handled per train.

Though the ton is a more accurate and satisfactory unit for operating purposes than the car, experience has shown that even the ton, though it is a basis which does not vary, does not give the desired results in all cases. The reason is this: The object aimed at in using a unit for loading locomotives is to have them always haul the heaviest possible load without stalling, or the heaviest possible load consistent with the desired speed. This object would be reached if some practicable unit could be used which had a fixed relation to the tractive power of the engines, because it is this power which we strive to gage in fixing the train load; or if there was a fixed relation between the ton and the power necessary to haul it.

Experience has demonstrated the fact that a given tonnage rating, which is all that is to be desired when made up of loads, is too heavy when composed of empties. A number of tests with a dynamometer car have shown that a given tonnage in empty cars requires from 7 per cent. to 50 per cent. more power to handle than the same weight in loaded cars; 7 per cent. more at a speed of about 10 miles an hour on a grade, and 50 per cent. more on comparatively level track at speeds approximating 25 miles an hour. A number of roads have recognized these facts and endeavored to overcome the difficulty in various ways. Several have limited the number of cars in a train; a number have added an arbitrary tonnage to the actual weight of empty cars, and a few have made careful tests with a dynamometer car to determine the resistance per ton of weight of all classes of cars, empty, partially loaded and fully loaded, and prepared tonnage rating sheets on the basis of the resistance shown by these tests. It is not necessary to discuss here which of these methods is the best. The facts are mentioned to show that, though the ton is a more accurate basis than the car, its original use has been modified because this did not furnish as accurate an operating basis as is desirable and to call attention to the fact that efforts are being made to arrive at a basis which shall measure as closely as practicable all the work to be done, or the resistance to be overcome.

It seems reasonable to conclude from these facts that it is recognized that the most desirable operating basis is that which most nearly approximates the capacity of the engine and, as nearly as practicable, includes all the resistance to be overcome; all the work to be done. It is true that usually the weight of the locomotive and waycar are not included in tonnage ratings, simply because these are always the same for a given class of each, are a constant part of freight trains and were taken into account in making the ratings originally which, if included, must be subtracted from the ratings in making up trains to determine what the weight of the train should be between the waycar and tender. Hence nothing is gained by including them and useless work is saved by omitting them. In this connection it is well to bear in mind that a tonnage rating is only a measure of a locomotive's capacity for work, and is not a measure of the work done.

When the ton was established as an operating basis for making up trains and had shown its value, it was but natural it should be considered as a basis for motive power statistics. The fact was recognized that the mile, which had been universally used as a unit of comparison, was by no means even

an approximately close measure of work, because it gave only the distance through which work was done, regardless of the capacity of the motive power and its actual performance. Its use gave the same credit to a narrow gage as to the most powerful engine built for a trip over the same length of track, whatever the load each handled. The tonnage hauled would give a more accurate measure of the work done than the mile, but it required little consideration to show that the distance over which the tonnage was handled was a very important factor in measuring the work by which to judge efficiency, for, if used, two engines handling the same tonnage would receive the sam3 credit, though one handled it twice as far as the other. Hence, the ton-mile, which shows both the weight moved and the distance over which it is moved, thus giving a more accurate measure of the work done, has been quite generally adopted as the unit for measuring the cost of locomotive service, furnishing another illustration of the tendency of modern railroad men to measure as closely as practicable the work done as a basis of comparison; or rather an illustration of modern clear thinking.

It is interesting to recall that Watt, the inventor of the modern steam engine, that he might have a measure of the capacity of his machines, devised and used the horse-power, which may be defined as the power which will raise 33,000 lbs. 1 ft. in one minute, and contains the elements of weight, distance and time. In the evolution of the basis of railroad motive power statistics it first included only the element of distance and has but recently included that of weight, still leaving out the important item of time or speed. This lack has, however, been supplied in a measure by grouping the statistics under several heads, as passenger, freight and switching service, so that the influence of speed on the amount of work credited is largely discounted by the fact that, because of this grouping, the extremes are much less than if all classes of service were thrown together into one group. This is another instance showing the growing appreciation of the general principle that the basis of statistics should be such as to furnish the closest practical approximation and that they should include all essential items.

There has recently been started a discussion as to whether the ton-mileage of the engine should be included in the ton-mileage totals to be used in determining the efficiency of the motive power department. In view of the growing practice to use such a basis for statistics as shall approximate as closely as possible the work done, it would seem that the decision could be only an affirmative one. Still it may be of service to discuss the matter somewhat at length.

I am convinced that a majority of those who would leave the ton-mileage of the engine out of motive power statistics do not have clearly in mind the different objects in view by the general manager, the general superintendent and the superintendent of motive power in keeping statistics. I am led to this conclusion by their remarks, some of which are quoted herewith. "The essential thing for a railroad company is what an engine does behind the tender." Again, "It seems to me that the general manager of a road wants to know what the engine is doing; he wants to see how much tonnage the engines are hauling behind the tender." These statements are certainly correct, but apparently the authors draw the conclusion that "Therefore the efficiency of the motive power department should be judged on this basis." It is to the correctness of this conclusion that I take exception.

It occurs to me that the general manager, while investigating what the engines are hauling behind the tender, will not hold the superintendent of motive power responsible, if the results of the investigation are not satisfactory, but rather the general superintendent, because he is the officer who is responsible for these results and not the superintendent of motive power, who has practically no control of results "behind the tender." He would judge the capacity of the superintendent of motive power on the basis of the cost of the work for which he is responsible, which, in my opinion, cannot be determined on the basis of the efficiency of the general superintendent. It seems clear that, while the general manager, the general superintendent and the superintendent of motive power have much that is of common interest and each should receive and study the statistics of all, still each has a special field which is not the same in the case of any two, and therefore one set of statistics cannot serve the best interests of all. It seems equally clear that each department should be given statistics which will serve its interests best, by which it can be judged most correctly, and only by so doing can the greatest efficiency and responsibility be reasonably expected.

The chief concern of the general manager is the relation of tonnage and revenue; that of the general superintendent the relation between theoretical and actual tonnage and between net and tare tonnage, while the superintendent of motive power should study chiefly the relation between the expenditure for which he is responsible and the output of work realized from it, whether revenue producing or not. In short, the problems of increasing net revenue, of securing the best service from engines and men while on the road, and of designing the most economical engines and keeping them at their maximum efficiency for the least money, are quite different. If this is a fair statement I cannot well see how one set of statistics can be made to do justice to all these interests. The conditions now and a few years ago are quite different. Then the profits were greater, competition not so sharp and the necessity of statistics, the best adapted to give reliable information, not so great. Under present conditions accurate knowledge, at least as accurate as one's neighbors, is essential.

It seems to me very plain that the best interests of all three can be served only by a set of statistics for each, the best adapted to judge the capacity of each, and that these can be furnished without prohibitive expense. By the use of properly prepared blanks which would show in separate columns revenue ton-miles, gross ton-miles and net ton-miles and any other items desired it is a very simple and inexpensive matter to provide the tonage required.

It is quite probable that a considerable part of the opposition to recommending and approving the use of these sets of statistics, especially that for the motive power department, is due to the belief that the cost of furnishing the necessary ton-mileage figures will be prohibitive. An investigation will show that this fear is not well founded. In all probability the ton-mileage back of the tender will be compiled for the general superintendent. That these figures may be used as a proper basis for the statistics of the superintendent of motive power, it is only necessary that the ton-mileage of the engine be added. On the Chicago, Rock Island & Pacific this is done in the office of the superintendent of motive power and the expense is that "of one day's work per month for our statement clerk." From the Northern Pacific the information is obtained that "it must be nominal, inasmuch as no special labor is involved." The car accountant of the Burlington & Missouri River writes: "We find it difficult to say how much extra it costs to compute ton-mileage of way cars and engines, but believe that $6 per month would cover it."

Though the ton-mileage of the engines is included in the motive power statistics of the Chicago, Burlington & Quincy and of the Southern Pacific, I have received no estimate of the cost of this work, but from the facts given believe it safe to say that the expense should not exceed $75 per year. This item is so small because the ton-mileage for each engine is a constant for each operating district, and a table of these constants having been made, it costs only the time necessary to add them to the figures for the train back of the tender, which have already been made, to obtain the ton-mileage of the entire train.

While the superintendent of motive power may be, and should be, interested and posted in the matter of revenue ton-mileage, and the relation between theoretical and actual and between loaded and empty ton-mileage, he can control these only to a very limited extent, and therefore can be held re-

sponsible for results in these directions only indirectly. It follows therefore that his efficiency cannot be fairly judged on either of these bases. What, then, should be the basis? It is reasonable to conclude that it should be one which is a just measure of the results for which he is responsible, and hence should show the relation between the money he is responsible for and the work produced by it. In short, the cost of his department work per gross ton-mile, the ton-mileage to include all that is produced, whether revenue producing or not.

If the ton-mileage of the engine is omitted there will be no credit against which to charge wages, supplies and repairs when an engine is run over the road light, and no proper credit when hauling only a way car; no credit for these charges on account of the expense incurred because of the work necessarily done by the engine in moving itself when hauling a train. That these items frequently amount to a considerable proportion of the total will presently appear. In my opinion Mr. Rhodes, Assistant General Superintendent of the Burlington & Missouri River, sounded the keynote as to the correct line of reasoning when discussing this matter before the American Railway Master Mechanics' Association last June. He said, in part: "I believe with the men operating the head end, that a great deal of economy can be produced by getting their co-operation, and to get their co-operation you must show them figures and results to entirely secure them with you, and you must show them that your figures are fair; that is to say, that you are measuring these men properly. I believe that if you leave out a portion of the tonnage that helps to consume the coal and other materials used on the engine, you are not going to be able to put yourself in a position to say you are entirely fair in your method of measuring." If it is conceded this is a fair statement and logical reasoning when applied to the records by which engineers and firemen are judged, I can see no good reason why it is not correct when applied to the records made by the officers who are responsible for the performance of the motive power department. Nor can I see any good reason for the unnecessary expense of two sets of ton-mileage figures for this department; one including the ton-mileage of the locomotive by which to judge the efficiency of the enginemen, the other, excluding the ton-mileage of the locomotive, by which to judge the department as a whole.

It is perhaps only a coincidence that most of those who oppose including the ton-mileage of the engine are connected with railroads which operate through comparatively level country, and therefore are not familiar with the conditions confronting those connected with roads not so favorably located, but it would not be surprising if this lack of experience accounts for the position they take. Before considering their conclusion as a final one they should know that there are a number of roads with heavy and continuous grades where the use of double headers, three locomotives to a freight train, helper engines for both freight and passenger trains, and a considerable percentage of light engine mileage are necessary to economical operation; a number of districts where five car passenger trains necessitate the use of three heavy locomotives, where freight trains seldom have less than three, where light engine mileage frequently and usually reaches sixty per cent. of the total, and where more than thirty per cent. of the total ton-mileage is that made by the engines; entire divisions where the helper engine mileage is from twenty-five to forty per cent. of the total. Had these facts been understood by those who are accustomed to but one engine per train, whose passenger engines handle from ten to fourteen cars and whose freight engines haul from fifty to seventy cars, with whom the light engine mileage will average nearer six than sixty per cent. of the total and the engine ton-mileage nearer ten than thirty-five per cent., I very much doubt if they would have been quite so sure that the engine ton-mileage should not be credited to their department against which to charge their expenditure. I am quite certain they have not taken into consideration one and a half per cent. grades seventy miles long or four per cent. grades nearly twenty-five miles long.

If the recommended practice in regard to ton-mileage for motive power statistics should omit that of the engine, I am persuaded that a number of roads which must contend with heavy grades will not be convinced of the justice of following the recommendation and decline to do so. If this is a fair estimate of the opinion prevailing on such roads, will it not considerably increase the probabilities of having the recommendation more generally adopted if the ton-mileage of the engine is included? If it is included, it seems reasonable that it would not in any way destroy the usefulness of the statistics for roads with slight grades, as shown by the opinion of the Superintendent of Motive Power of a road noted for the practically level grade over which it operates. Though at that time he was not in favor of including the ton-mileage of the engine, he said: "I think in analyzing the figures and seeing how much it amounts to, to put the weight of the engine in these ton-mile figures does not amount to one per cent. difference." This was said in regard to the influence on a comparison of the fuel records of including, as compared with excluding, the ton-mileage of the engine.

It may appear to some that an extended argument like this is a waste of time because each road will decide for itself which practice it will follow. Possibly this is true. Still, though I have no faith that the practice of comparing statistics of different roads results in bettering records, because scarcely two roads can be found where operating conditions are the same or can reasonably be made the same, such comparisons will in all probability be made, and at present such comparisons are considered of such importance that committees have been appointed by the American Railway Association, the Association of American Railway Accounting Officers and the American Railway Master Mechanics' Association to consider and report on uniform methods of preparing railway statistics.

On several occasions the argument has been made that the ton-mileage of the engine should not be included, as this would not give proper credit to unusually good locomotive designs, in which the greatest power had been obtained for the lightest gross weight of the machine. An able designer has stated the case in the following words: "I believe if we can produce an engine with the same tractive power and of lighter weight, so that the weight of the engine is replaced in part by the weight of the train, that that engine is certainly entitled to the benefit of the extra tonnage that it would haul; whereas, if we included the weight of engine and tender, there would be no extra credit for that design."

Assuming the argument is as strong as its author could possibly hope to claim, there still remains the fact that, before it is allowed to settle the question, we must decide whether the best interests of the motive power department as a whole should be sacrificed in order to give the Mechanical Engineer due credit for skill and ability. While I believe I fully appreciate the importance of good designs and their effect on the efficiency of the department, it seems to me the efficiency of the Mechanical Engineer can be properly judged without sacrificing the best interests of the department as a whole, and that this would be the result if its basis for statistics is determined by the argument just quoted. Aside from this feature of the case, I believe it can be shown that the argument is not as weighty as may at first appear.

In so far as the locomotive proper is concerned, I believe I am warranted in concluding that the steam pressure and dimensions of the cylinders and drivers are proportioned to the weight on the drivers and that the weight on the drivers determines the maximum tractive power of the machine; that the cylinder power is seldom less than 22 or more than 26 per cent. of the weight on the drivers; and that the effect of this small variation would scarcely be found whether the weight of the engine proper is included in the ton-mileage or not. It is true that on prairie roads the tractive coefficient

may be somewhat higher than on those operating on heavy grades, because with the former the maximum tractive power is seldom used except in starting, but on heavy grades the weight on the drivers determines the capacity of the locomotive most of the time, and under this condition superiority of design has little opportunity to produce a lighter engine capable of handling a heavier load. In regard to the locomotive proper I believe the following statement a fair one. Superiority of design can affect its tractive power but little, if any, because this is fixed by the weight on the drivers, though there are many opportunities to lighten the weight of the frames, cylinders and running gear so as to secure boilers of greater size and heating capacity.

As to the tender, I believe it will be conceded that its capacity for water and coal are determined by operating conditions and not by the designer; hence his field is limited to the lightest weight for a given capacity. A tender having a capacity of 10 tons of coal and 6,000 gallons of water would weigh about 110,000 lbs., ready for service, and is suitable for a locomotive having 20 by 26-in. cylinders, carrying 200 lbs. steam pressure, with drivers 63 ins. in diameter. Such an engine should easily handle 1,500 tons of train on a prairie road. The weight of the coal and water in such a tender would be 69,800 lbs., making the light weight of the tender 40,200 lbs., or 20.1 tons. Its light weight would therefore be but 1.3 per cent. of that of the train back of it, and is such a small proportion of the total that, if we assume a designer capable of accomplishing the impossible task of reducing the weight of the tender to zero, I believe it will be admitted without argument that we could not reasonably expect to find the results of his skill in our records, whether the tonnage of the tender is included in our statistics or not.

THE DRAFT GEAR SITUATION.

By Edward Graftstrom, Mechanical Engineer Atchison, Topeka & Santa Fe Railway.

Since my review of this subject in the American Engineer and Railroad Journal (June, 1900, page 185), several interesting developments have taken place which are worth the scrutiny of the Master Car Builders' Committee having this subject in charge, as furnishing data on the present state of the art.

The Westinghouse tests of the friction gear at Wall and Wilmerding have shown the possibilities of this excellent device; the tests of draft riggings under the drop testing machine at Topeka have demonstrated that there are draft riggings strong and substantial enough to satisfy the most exacting demands; and the road test of twin spring and tandem spring draft gears on the Santa Fe has been corroborated by similar tests on other roads, all of which have brought out the fact that a well-made double spring draft rigging is fully able to meet the conditions of the service of the present day.

It is to be regretted that these tests were not conducted under the official supervision of the committee, so that the results could have been reported and discussed at the coming convention. This notwithstanding these tests have become a matter of history through the medium of the railroad journals, and no member of the association with the interest of the company he serves at heart can afford to ignore them.

Few, if any, of the mechanical railroad officials will deny the superiority of the friction draft gears. Yet when the rush for new cars came this year there were few, if any, who cared to go before the management and on their own responsibility present specifications calling for the friction draft gear. The price of this device is so high compared with that of spring draft gears and the benefits accruing from it are so remote in time that no one can yet say what the return for the additional investment will actually amount to. If the friction draft gear will lengthen the life of a car it may be fifteen years before figures will show it, and could it not then as well be ascribed to other improvements in car construction? Besides, who can tell whether or not the cars of to-day will not anyway be obsolete fifteen years hence?

If it is a question of repairs, of which the friction draft gear would have a large portion, we have at present no figures to compare it with save for single spring draft gears, for the modern double spring attachments have not yet been in service long enough to furnish figures for this purpose.

The Topeka drop test showed conclusively that some of the double spring draft gears are strong enough to promise an important reduction in the cost of maintenance of cars. This item of expense is therefore certain to be lessened with the passing of the single spring gear, be it supplanted by double springs or friction gear. The road tests on the Santa Fe and elsewhere have also demonstrated that two good springs offer a cushion sufficient to protect the car from ordinary shocks.

From this point of view the whole question resolves itself thus: What injury will this recoil, of which we have heard so much recently, do to the car? For answer let us analyze the action which takes place when two cars come together. First, the draft springs are closed up, and if the force of impact is more than what is expended in compressing them, the followers will come up against their stops before the impinging car is brought to a rest. At that moment the torsion of the springs will reassert itself, sending the cars apart until the draft springs have regained their normal free height, after which the momentum of the cars in their recoiling movement will be absorbed in compressing the springs again, this time against the other set of followers and stops. The cars now come to a rest before the springs are fully compressed or the followers brought home, and at the moment they are quiescent the springs will again commence to straighten out and pull the cars toward each other, passing their normal point and going beyond it to a still lesser extent than at first. This will be repeated until the force of impact has been entirely spent in producing oscillations in the springs, to be finally overcome by the torsion of the steel bar. It will thus be seen that the recoil in a draft rigging with double sets of followers is always acting against the same spring that caused it. With the present draft springs only a few oscillations are needed to consume the impact. Anybody can convince himself of how quickly the shock is absorbed by the springs by blocking a car and pulling out the coupler with an engine as far as it will go, and then releasing the coupler; the recoil will not reach a lead pencil held between the striking plate and the coupler horn. How the recoil can injure a car is not clear, but that it would snap the old link and pin connection in two was due to the slack and consequently to the momentum acquired by the recoiling car before the retarding influence of the spring was felt. With the limited play in the M. C. B. coupler the conditions ought to be different, however.

If this line of reasoning is accepted as logical, it follows that the recoil of the draft springs is not more injurious to the car than the recoil of the bolster springs. As long as the latter do not come together solid no damage will be done to the car or lading, and why should this not be equally true of the draft springs? According to this argument the possibilities in spring capacity of draft gears have not yet been exhausted. In point of fact, the writer believes that the main spring used in the Westinghouse friction gear would give better results as a draft spring than the present M. C. B. spring, or possibly a 10-in. spring would be more desirable. Then there is the recourse to graduated springs with a lighter inner coil which has been suggested but not yet tried as far as the writer knows.

The principal advantage of the friction gear above the spring draft gear lies consequently in its large capacity, or, in other words, in the greater resistance offered before the cars come together solid, while at the same time there is the requisite sensitiveness to light blows. By using graduated springs in

sufficient number this effect could probably be closely reproduced, but the cost of such an arrangement would perhaps come as high as that of the friction gear.

Before leaving this subject one more phase of it should be referred to which brings in the "personal element." When the M. C. B. coupler became general the enginemen felt less hesitation about hitting the cars hard in the yards while making up trains, knowing that there would be no men between them making couplings. Likewise since the friction gear became introduced on some roads it has been observed that the yard crews have developed an investigating turn of mind of their own, and when they send a cut of cars against another, and the cars are labeled "Westinghouse Friction Gear," the men try to see for themselves if what is claimed for the device is true. The writer has it from more than one source that such cars are getting rougher treatment than others in the yards, and when the superintendent of motive power has had his attention called to this diversion his explanation has been that these cars must take their chances with the rest without special protection. However, be this as it may, this practice would tend to reduce the durability of cars with friction gears and should be guarded against in the interest of the "art."

To the Editor:

The article entitled "The Draft Gear Situation," while dealing with this subject apparently in quite a comprehensive way, contains many ideas which might mislead those who have not given the subject special consideration.

It is asserted that "the tests of draft riggings under the drop testing machine at Topeka have demonstrated that there are draft riggings strong and substantial enough to satisfy the most exacting demands." The most severe punishment to which the devices tested at Topeka were put resulted from the fall of a 1,640-lb. weight through 20 ft. A simple calculation of the energy resulting from this blow will show that it is far below the capacity of a single Westinghouse friction gear, while in service two such gears, with double the capacity of a single gear, are always concerned in absorbing the energy imposed upon them when cars fitted with these devices are run in trains. The Topeka tests were not only by no means such as would determine whether or not the draft gears were substantial enough to satisfy the most exacting demands, but in these tests the gear was only tested by impact. This is manifestly inadequate as the strains set up by pulling the cars are really the most important. The draft rigging can and should generally be not required to transmit the strains arising from the impact of cars colliding, but it must take all the strains of extension. A failure here results in a break-in-two, with its attendant danger of much greater damage to cars and lading.

Again, the author makes no distinction in his comparisons between the yielding and cushioning part of the draft rigging of cars, and the attachments which secure this yielding member or members to the sills or other parts of the car structure proper, but treats them, individually and collectively, under the somewhat vague term of "draft gear." It is well known that the device called the Westinghouse Friction Draft Gear is an appliance for supplying the greatest possible yielding resistance, both in tension and compression, between the draw-bar and the car structure. There can be no rivalry between this and what are called spring draft gears in the communication above mentioned, as these gears consist simply and solely in improved methods and stronger appliances for attaching the ordinary draft springs, either single or double, to the car. The friction gear is really a substitute for the draft springs and as such manifestly can be attached to the car as strongly. Laying aside then the question of the strength of attachments, the question under consideration resolves itself into one of the value of a yielding resistance, in the line of draft, of at least 4¼ times the capacity to cushion shocks and suddenly imposed strains of even the strongest double springs. This great capacity is also secured with the practical absence of recoil.

There are many locomotives running to-day the tractive power of which is more than sufficient to exhaust the capacity of the double springs on a direct pull, permitting all strains due to jerks from slack in the couplings, whether loose or spring slack, to come as uncushioned blows or stresses upon the draft attachments. That new attachments, under these conditions, are not broken in tests signifies little in judging the value of appliances which will absorb the greatest tractive power of the heaviest locomotives, and have several times this amount of yielding resistance still left to absorb stresses and shocks due to slack, before their capacity is exhausted.

No one would think of endorsing the design of a structure or machine because it would not be destroyed by the greatest load it was to carry if imposed a few times. Mechanical structures, especially those subject to alternating stresses, must not only not fail under maximum stress, but must, like the Westinghouse friction draft gear, have a factor of safety of several times its ultimate loading when, as here, this is considered the maximum traction of the locomotive.

In regard to the effect of the recoil of the draft springs, we cannot accept the conclusion of the author that the recoil of the draft and bolster springs is comparable in action or in the effect upon the car structure. The analysis made in the article of the action of a spring under suddenly and continually applied load is quite correct and applies well to the conditions under which a bolster spring works. It is, of course, possible and often occurs that a draft spring is loaded similarly, under which conditions the author's reasoning and conclusions would apply. This, however, is by no means always the condition under which the draft spring recoils and it is that under which the recoil is disastrous which needs consideration. Let us follow the author's analysis:

"First the draft springs are closed up and if the force of impact is more than what is expended in compressing them, the followers will come up against their stops before the impinging car is brought to rest. At that moment the torsion of the springs will reassert itself, sending the cars apart until the draft springs have regained their normal free height, after which the momentum of the cars in their recoiling movement will be absorbed in compressing the springs again," etc.

Suppose now when "the impinging car is brought to a rest," in addition to the recoil of the springs, a sudden and considerable force is applied in the same direction, as often happens either from the locomotive or the inertia of other cars in motion; this force, itself perhaps almost as great as the couplings will stand, has added to it not only the energy stored in one double spring and given out in its recoil, but as many times that energy as there are springs in compression released under this condition. This rapidly accumulating force is finally expended at some point or points in the train where conditions of relative motion of the cars are different either by brakes set in the rear or different velocities of cars in one part of the train than in another, as in passing through sags or over hog-backs. It is readily seen that there is no analogy here to the action of bolster springs and it is this cumulative action, resulting from the recoil of the draft springs and increasing with their capacity, that causes the sometimes mysterious break-in-twos in emergency stops with long trains of air-braked cars, always, as should be the case, more prevalent with empty than loaded cars.

The greater the rigidity of the car itself the more severe the results of this recoil will be and with the large increase in steel-car and underframe construction, great as the advantage in the very large capacity of the Westinghouse friction draft gear is, it is by no means certain that the absence of recoil will not prove of still greater service in lessening the expense of maintenance and improving the safety and reliability of freight train movement.

In regard to the so-called "personal element," in the first place, breakages of draft rigging in yards or in switching operations are, of course, expensive and objectionable on this account, but they do not approach in importance breakages in draft rigging on cars in trains in motion as breakages here are not, as in the former case, confined to the damage of the rigging, but may, in addition, wreck the train. Again, the same objection, viz., the "personal element," was originally urged against the use of power brakes. The train men would be reckless and approach danger points at speeds which would cause more wrecks and disasters. Such may, in some cases, have been true, but the failure to properly train and discipline employees did not stop the progress in railroad operation due to the introduction of a valuable improvement thirty years ago, nor need we fear that it will do so to-day.

E. M. Herr.

CONFLICTING OPINIONS CONCERNING COMPOUND LOCOMOTIVES.

As the compound locomotive is likely to be given considerable attention, as usual, at the approaching Master Mechanics' Convention, it will be interesting to note the following quotations taken at random from the proceedings of that association.

Mr. A. J. Pitkin (Proceedings for 1890)—I believe thoroughly in the two-cylinder type as the proper form for compounding.

Mr. P. Leeds (Proceedings for 1890)—I would not at present recommend the purchase of compound engines, * * * nor do I believe they will ever do all that is claimed for them. * * * Quoting Mr. Angus Sinclair—It is an open question, there being the most violent conflict of opinion on the subject among locomotive superintendents in Europe, where they ought to know all the comparative values. A month spent in the home of the compound locomotive took away a great deal of the faith previously held in that type of engine.

Mr. S. M. Vauclain (Proceedings for 1891)—When you come to compound standard engines with cylinders 22 x 24 ins. in diameter by 28-in. stroke, you can see that you would not have road-width enough to put a low-pressure cylinder on one side of the engine and get by on the road. I do not think anybody would want to use a 36 to 38-in. low-pressure cylinder for every-day use. We, therefore, thought we would adopt a four-cylinder arrangement, and with that idea we brought out what is called the Baldwin Compound Locomotive, of which I am the patentee. * * * We know that there is an economy in the two-cylinder compound. It was proved years ago, as far back as the original patent dates. But that economy is not sufficient so we go to the four-cylinder compound.

Mr. A. J. Pitkin (Proceedings for 1902)—I simply wish to call attention to the report sent to Mr. Gibbs by Mr. Small giving the equalization of work in the two-cylinder compounds, believing as we do thoroughly in the two-cylinder compound engine as being a case of the survival of the fittest.

Mr. J. N. Lauder (Proceedings for 1892)—But I want to say it seems to me unnecessary to build and maintain four cylinders on locomotives, with all the attending expense of repairs, when you can get equally good results out of a much simpler form of engine.

Mr. J. N. Lauder (Proceedings for 1894)—I think that the past year's experience in this country with the compound engine has plainly brought about a feeling among the railroad companies and railroad men in general, that it is very much of a question whether there is not to be a compound engine that will successfully compete with the best type of simple engine. * * * I believe we are going to get compound engines within a few years that will give us greater economy of operation than anything we have at the present time.

Mr. D. A. Wightman (Proceedings for 1895)—I am an advocate of the compound locomotive of the two-cylinder type. I think those who have closely followed what might be called the rise and fall of compound locomotives during the past three or four years have not failed to discover a growing faith in the value of double expansion. * * * The conservative reports of our European friends have been largely ignored, and in place of economies of 10 to 25 per cent., the railway officers of this country have been flooded with reports of tests showing a saving in fuel of 25 to 45 per cent.—reports in many cases so grossly misleading that as one reads and turns the pages he is surprised at not finding them signed by Ananias. These statements have doubtless accomplished, to some extent, the object sought; for it has been said that compound locomotives have been sold largely in Wall Street, so to speak; and certain it is, they have been bought sparingly upon the advice of railway master mechanics. * * * It may be unnecessary for me to add that I think the most successful double-expansion locomotive of the future will have but two cylinders.

Mr. R. H. Soule (Proceedings for 1897).—The compound locomotive is still in the balance.

Committee Report (Proceedings for 1900).—The data obtained is quite too meager to permit of drawing any definite conclusions as to what average result might be expected from the compound under any given set of conditions.

PERSONALS.

Job H. Jackson, President of the Jackson & Sharp Company, died at Wilmington, Del., May 23.

Mr. H. T. Herr has been appointed Division Master Mechanic of the Chicago & Great Western, with headquarters at St. Paul, Minn., in the place of Mr. J. M. Robb, resigned.

Mr. F. N. Hibbits, Division Superintendent of the Erie at Carbondale, Pa., has been appointed Mechanical Engineer of the Union Pacific, with headquarters at Omaha, Neb.

Mr. William Forsyth, who is well known to the readers of this journal, has joined the staff of instructors at Purdue University and will have charge of the classes in locomotive and car design.

Mr. J. F. DeVoy, Draftsman for the Brooks Locomotive Works, at Dunkirk, N. Y., has been appointed Chief Draftsman of the Chicago, Milwaukee & St. Paul, with headquarters at West Milwaukee, Wis.

Just before going to press a notice is received of the death of Frank W. Deibert, Assistant Mechanical Superintendent of the Baltimore & Ohio, at Newark, O. Mr. Deibert was formerly with the Chicago, Milwaukee & St. Paul.

Mr. R. O. Cumback, General Foreman of the locomotive department of the Central Railroad of New Jersey, has been appointed Superintendent of Cars and Machine Shops of that road, with headquarters at Elizabethport, N. J.

Mr. G. R. Henderson, who is well known to our readers, has resigned as Assistant Superintendent of Motive Power of the Chicago & Northwestern to accept a position with a similar title on the Atchison, Topeka & Santa Fe, where he succeeds Mr. R. P. C. Sanderson, recently resigned.

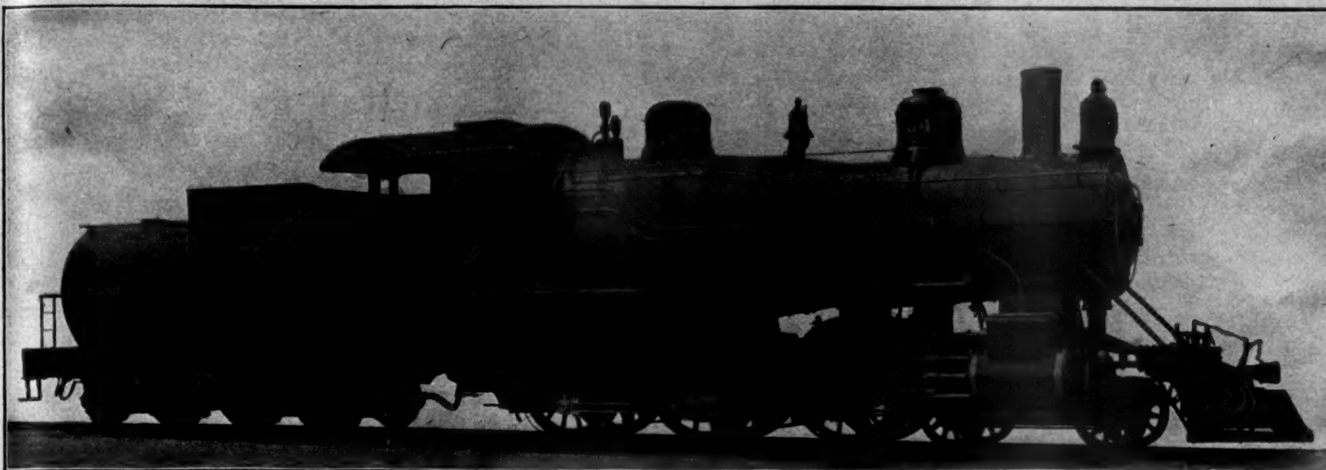
Mr. A. J. Ball has resigned as Assistant Superintendent of Motive Power of the Cincinnati, Hamilton & Dayton to accept the position of Superintendent of Motive Power and Equipment of the Toledo, St. Louis & Western, with headquarters at Frankford, Ind., succeeding Mr. J. S. Turner, resigned.

Mr. Samuel R. Callaway has resigned the office of President of the New York Central, to accept the presidency of the American Locomotive Company, an organization including the principal locomotive works of this country, with the exception of the Baldwin Company. Mr. Callaway is 50 years old and began a most successful railroad career in 1863, when he entered the services of the Grand Trunk Railway. Since that time he has held the offices of General Manager of the Chicago Grand Trunk, Vice-President and General Manager of the Union Pacific, President of the Toledo & Kansas City, President of the Lake Shore & Michigan Southern and of the New York Central.

BOOKS AND PAMPHLETS.

Biographical Directory of the Railway Officials of America. Edited and compiled by T. Addison Busbey, Associate Editor of the Railway Age. 1901 edition, 613 double-column pages. Published by the Railway Age, Chicago.

This volume gives in concise form the history of the professional career of every railroad man in this country who has attained an official rank. The changes and interesting development in the career of these men are simply told by the statements of the different positions through which they have worked and the time spent in each position. The present edition contains sketches of the lives of 4,990 men, of these 1,344 did not appear in the last preceding volume of 1896, and about 1,223 of those whose names did appear in that edition have either died or entered into some other work. Many interesting things are told by an examination of the book, such as the road by which each man has traveled in preparing himself for his present position. Very few of these records show a life-long service with one company, but tell emphatically of the chances and changes of railroad life. The answers to questions usually asked of a railroad man after he has reached official rank are always interesting and instructive and for these reasons, combined with its general usefulness as a directory, makes it a volume worthy a place in every railroad office. It is well arranged and well edited.



TEN-WHEEL PASSENGER LOCOMOTIVE—ILLINOIS CENTRAL RAILROAD.
With Vanderbilt Boiler and Tender.

W. RENSHAW, *Superintendent Motive Power.* BALDWIN LOCOMOTIVE WORKS, *Builders.*

Cylinders: 20 by 28 in. Boiler pressure .... 180 lbs.
Wheel: Driving .... 63 in.; engine truck .... 33 in.; tender wheels .... 33 in.
Weights: Total of engine .... 167,880 lbs.; on drivers .... 137,040 lbs.; total engine and tender .... 284,000 lbs.
Grate area and tubes: Grate area .... 33 sq. ft. Tubes .... 350-2 in. 13 ft. long.
Firebox: Length .... 94 in.; Diameter .... 63½ in.
Boiler: type, ... Vanderbilt corrugated firebox. Diameter .... 66 in.
Heating surface: Tubes .... 2,362.5 sq. ft; firebox .... 135 sq. ft.; total .... 2,497.5 sq. ft.
Wheel base: Driving .... 13 ft. 6 in.; total of engine .... 24 ft. 4 in.; engine and tender .... 53 ft. 3 in.
Tender: Eight-wheel; water capacity .... 5,000 gals.; coal capacity .... 12 tons.

A new and improved design of the Vanderbilt boiler and a novel cylindrical tender, also built to Mr. Vanderbilt's designs, have been applied to a 10-wheel passenger locomotive recently built by the Baldwin Locomotive Works for the Illinois Central Railroad. This engine is similar in general to those of the standard 10-wheel type in use on this road since 1898. It has, however, 100 sq. ft. more heating surface and 6 sq. ft. more grate area than those of the ordinary type of boiler, the weight being correspondingly greater. In this engine the corrugated firebox is 63½ ins. in diameter, which is the largest yet constructed, the grate area being 33 sq. ft. The improvement in the boiler lies in the arrangement of the firebox and tubes with relation to the outer shell. Provisions are made in this case to receive the stresses of longitudinal expansion and contraction in straight lines. The construction of the tender is a novelty in that the cistern is cylindrical with a built-up coal space with a large capacity—12 tons—at its front end. This construction greatly simplifies the tender frame by reducing the number of longitudinal sills and bringing them close together. Lightness, strength and compact form appear to be the features of this tender. Its form seems odd at first, but it is by no means ungainly. In fact, the appearance of the engine as a whole is decidedly pleasing. We shall give our readers more of the details of this tender in a future issue. The following table contains the principal dimensions of the engine:

10-Wheel Passenger Locomotive, I. C. R. R. With Vanderbilt Boiler and Tender.
General Dimensions.

Weight on drivers	137,040 lbs.
Weight on truck	30,840 lbs.
Weight, total engine	167,880 lbs.
Weight, total engine and tender	284,000 lbs.
Cylinders, diameter	20 ins.
Cylinders, stroke	28 ins.
Cylinders, valve	American balanced
Boiler	Vanderbilt type
Boiler, diameter	66 ins.
Boiler, thickness of sheets	⅝ in. and ¾ in.
Boiler, working pressure	180 lbs.
Boiler, fuel	Soft coal
Firebox, material	Steel
Firebox, length	94 ins.
Firebox, width	57 ins.
Firebox, diameter	63½ ins.
Firebox, thickness of sheets, sides	⅜ in.
Firebox, thickness of sheets, tube	⅝ in.
Tubes, material	Iron
Tubes, number	350
Tubes, diameter	2 ins.
Tubes, length	13 ft. 0 in.
Heating surface, firebox	135 sq. ft.
Heating surface, tubes	2,362.5 sq. ft.
Heating surface, total	2,497.5 sq. ft.
Grate area	33 sq. ft.
Driving wheels, diameter outside	63 ins.
Driving wheels, diameter of center	56 ins.
Driving wheels, journals	8½ ins. by 10 ins.
Engine truck wheels, diameter	33 ins.
Engine truck wheels, journals	5½ ins. by 12 ins.
Wheel base, driving	13 ft. 6 ins.
Wheel base, rigid	6 ft. 9 ins.
Wheel base, total engine	24 ft. 4 ins.
Wheel base, total engine and tender	53 ft. 3 ins.
Tender	Vanderbilt type
Tender, diameter of wheels	33 ins.
Tender, journals	5 ins. by 9 ins.
Tender, tank capacity	5,000 gals.
Tender, coal capacity	12 tons

No system of shop organization can be satisfactory and complete that does not show the progress of each day's work, and that does not show the cost of each piece of work, together with the general and shop establishment charges. Mr. A. Hamilton Church, in a recent issue of "Engineering Magazine," gives the following principles on which a good system should be based. Such a system should readily distinguish between incidence of indirect shop expenditure and incidence of office and sale-organization expenditure; between the incidence of shop expenditure in one shop and in another, and between different classes of work in the same shop. There should also be so close a control over the stores and shops that the present value of assets may be known at least once a month. This implies, as will be obvious to an accountant, that monthly balance-sheets must be furnished, with the advantages which a continuous audit give. There will also be, what is no less important, continuous stock-taking. The present state and cost of any order should also be known at any moment, without calculation or more than two references at the most.

To the Pan-American Exposition via the "Akron" Route.—This route is composed of the Vandalia Lines from St. Louis; the Louisville & Nashville Railroad from Nashville and Louisville; the Pennsylvania Lines from Indianapolis, Cincinnati; Dayton and Columbus, via Akron and the Erie Railroad, and is in daily operation with two through passenger trains to Buffalo each day from the places mentioned above. This route offers many advantages to tourists and a number of forms of tickets may be had, which offer various privileges. The Akron Route tickets to New York via Buffalo, over the Erie Railroad will secure the privilege of ten days' stop-over at Buffalo. This will be of particular advantage to those attending the American Railway Master Mechanics' and Master Car Builders' convention, at Saratoga Springs, June 19 to 26 inclusive.

EQUIPMENT AND MANUFACTURING NOTES.

Mr. Harry A. Norton, of the firm of A. O. Norton, Boston, is making an extensive trip abroad. He will visit the various agencies of the Norton Ball Bearing Lifting Jacks in France, Italy, Russia and Sweden.

Mr. G. E. Macklin, formerly Assistant General Sales Agent of the Pressed Steel Car Company of Pittsburgh, has recently been made General Manager of the company; and Mr. E. E. Forgeus, formerly with the Chicago Lumber Company, Chicago, has been appointed Purchasing Agent.

The Trunk Line and Central Passenger Associations have granted a reduced rate to those who will attend the Railway Master Mechanics' and Master Car Builders' conventions, at Saratoga, of a fare and one-third for the round trip. In order to get the benefit of the reduced rate it is necessary to purchase a ticket at full fare for the going trip and to obtain a certificate from the agent. This certificate when presented to the proper parties at Saratoga will entitle the purchaser to a return ticket at one-third fare.

The sale of the general machinery building shops of the Dickson Manufacturing Company to a combination of interests, also embracing the E. P. Allis Company and Fraser & Chalmers, has been completed. The Dickson Locomotive Works, formerly incorporated with the Manufacturing Company, have considerably enlarged their plant. A new forge shop is now being pushed to completion and a new foundry and erecting shop are also under construction. These extensions and improvements when finished will give a capacity to the works of 200 of the largest size modern locomotives per year. No changes are to be made in the management of the Dickson Locomotive Works by the change referred to.

One of the interesting exhibits at the Railway Master Mechanics and Master Car Builders conventions to be held this year, at Saratoga Springs, June 19 to 26, will be the Webb C. Ball Company's display of modern railroad watches. These watches are made to meet the requirements of close and fast schedules, and are products of this skilful and progressive firm. They are in every sense modern and their success as timekeepers is told by the adoption of this watch by many important railways.

The Williams safety automatic car window can be applied to old as well as new cars with very little trouble, as no part of the mechanism is above the window. The device is simple, durable, cheap and renders the window air-tight, dust-proof, free from rattle and trouble from shrinkage or swelling of the wood. The window is operated by pressing a push button placed either on top or at the side of the window sill. It can be opened to any desired height and is securely locked when in the closed position. This window is equipped with up-to-date fixtures and adds greatly to the comfort and good-will of the traveling public. By addressing Mr. Otis Williams, St. Johnsville, N. Y., any desired information regarding this automatic window will be furnished.

The Richmond Locomotive Works shipped twelve 16 x 24-in. ten-wheel passenger locomotives to the Finland State Railways, Helsingfors, Finland, on the Wilson Line steamer "Consuelo," which sailed May 3d. These locomotives are duplicates of ten engines built by the Richmond Works for the Finland State Railways last year, and this is the third order received from the same source. Two very recent orders received by these builders are for four 20 by 26-in. consolidation locomotives for the Alabama Great Southern Railroad and four 19 by 26-in. ten-wheel locomotives for the Richmond, Fredericksburg & Potomac Railroad. The principal dimensions of the Alabama Great Southern engines are as follows: Diameter of driving wheels, 58 ins.; driving wheel base 15 ft. 11 ins.; total wheel base, 23 ft. 11½ ins.; weight in working order, 142,500 lbs.; weight on drivers, 124,000 lbs.; 61-in. extended wagon top boiler; steam pressure, 200 lbs.; firebox, 102¾ by 41⅞ ins.; 271 2-in. tubes 14 ft. 4⅝ ins. long; tank capacity, 5,000 gallons. The principal dimensions of the Fredericksburg & Potomac engines are as follows: Diameter of driving wheels, 68 ins.; total wheel base, 24 ft. 4 ins.; driving wheel base 13 ft. 6 ins.; weight in working order, about 140,000 lbs.; weight on drivers, 102,000 lbs.; 62-in. straight top boiler; working pressure, 180 lbs.; 267 2-in. 14 ft. 5 ins. long; firebox, 96⅝ by 42 ins.; capacity of tank, 4,500 gallons.

The new buildings just added to the Otto Gas Engine Works were formally opened by a reception and entertainment given to the employees, by the officers of the company. About four hundred people participated and the event was a success in every way. General good feeling was strongly manifested by the employees and the company.

The Bullock-Wagner sales organization has established a district office at No. 1624 Marquette Building, Chicago. Mr. H. B. Foster, who has for about two years served the Wagner Company as sales agent, will be in charge of the office and will have the assistance of Mr. E. W. Goldschmidt, formerly of the Western Electric Company, in covering this important field.

At a recent public discussion of the smoke nuisance in Boston Mr. Edward Atkinson predicted the passing of the tall chimney and the substitution of the low stack of large area with draft produced by mechanical means. In this development the B. F. Sturtevant Company, of Boston, Mass., are taking a prominent part. He prophesied that the next generation would regard our chimneys as monuments to our ignorance left standing because they would not pay for taking down.

There is one very prominent and favorable feature which makes the lakes of New Hampshire popular with the fishing fraternity, and that is the exceptional facilities for reaching them. The General Passenger Department of the Boston & Maine Railroad, Boston, is issuing several descriptive pamphlets on outdoor sports—namely, "Fishing and Hunting," "Lakes and Streams," "Lake Sunapee"; either of which is sent to any address upon receipt of a two-cent stamp for each book. If you are a fisherman, send for them.

A report by Lord Cromer upon the finances of Egypt for the year 1900 embodies a statement made by Major Johnstone, President of the Railway Board, regarding the supply of "goods wagons" on the Egyptian Railway. The cars referred to were designed and built for this road by the Pressed Steel Car Company of Pittsburgh. He says: "Among the improvements effected during the year which has had the greatest effect is the putting into service of two hundred 30-ton American wagons ordered by my predecessor. The result has exceeded my anticipations; the complaint of want of wagons has almost ceased to exist, partly, no doubt, because the demand is not at present so great as it has sometimes been at this season, and partly from improvements in other branches of the service, but mainly owing to a great addition to our carrying power, which is represented not only by the capacity of the wagons, but by the fact that, owing to their extreme lightness, our goods engines can draw 20 per cent. more net load in these than in our ordinary stock. The result of the purchase has been a great gain in carrying capacity obtained in a very short time at a very small cost."

The Lehigh Valley Railroad will, about June 1st, place in service a new fast passenger train to run between New York Philadelphia and Buffalo and Chicago via Niagara Falls. This train will leave New York 10 a.m.; Philadelphia, 10.30 a.m., arriving Buffalo 9 p.m.; Chicago, 1.28 p.m. Returning, train will leave Chicago 11.45 a.m., arriving New York, 4.25 p.m.; Philadelphia, 4 p.m. The train will be equipped with all new cars and will be hauled by locomotives especially designed to make fast time.